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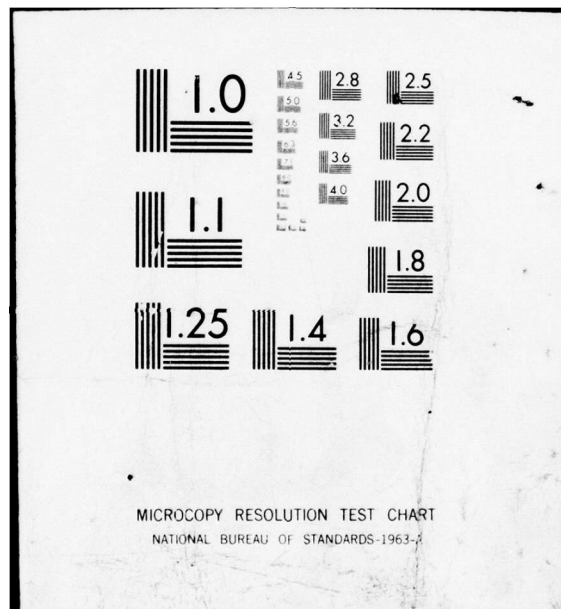
MICROCOPY RESOLUTION TEST CHART

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TECHNICAL REPORT TE-77-13

OPTICAL CONTRAST VARIABLE GATE CENTROID TRACKER FOR THE INTEL 3000 MICRO PROCESSOR

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

Advanced Sensors Directorate
Technology Laboratory

June 1977

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Redstone Arsenal, Alabama 35809

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MACRO code list
EAI PACER 100
Optical contrast variable gate centroid tracker

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a description of the optical contrast variable gate centroid tracker. Tracking flow charts and computer listings are also presented.

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CONTENTS

I. INTRODUCTION

The US Army Missile Research and Development Command's Imaging Seeker Algorithm Development Microprocessor System, which employs the Intel 3000 microprocessor, was used in developing this optical contrast variable gate centroid tracker. The tracker processes data taken from a 10K memory which has been "filled" with digitized data from a 100×100 element image produced by a Fairchild Charge Couple Device (CCD) 201 camera. A hardware description of this system is currently being prepared and will be published in a forthcoming report.

The major portion of the tracker program is micro coded and is called through macro-mnemonics which are used like subroutine calls. This macro instruction set is an emulation of the EAI-PACER 100 assembly language with some additions to allow for the specialized tracker mnemonics. The actual program listings for the micro and macro code are presented in the appendices.

II. MAIN TRACKER LOGIC FLOW DESCRIPTION

Figure 1 shows the main flow of the optical contrast variable gate centroid tracker. The macro code presented in Appendix A implements the tracker through the micro coded subroutines presented in Appendix B.

Block No. 1 in Figure 1 corresponds to sequence numbers 19 through 23 in the macro code of Appendix A. The START routine initializes I, J, K, and L for the minimum gate as shown in Figure 2. The octal ten in latch 6 will put out the cross hairs on the gate display. The WINDOW routine will load the window latches with the current I, J, K, and L as shown in Figure 3. The tracker will display its minimum gate with cross hairs when it stops on the pause instruction. This is a "cage" mode where the contrast of the target within the 2 by 2 gate will be tracked upon resumption of execution by single stepping past the pause.

Block No. 2 in Figure 1 corresponds to sequence numbers 24 through 48 in the macro code. The six in latch 6 will enable the status on the 10K memory to be loaded from the 100×100 CCD array and will also enable the frame request. The FRAMEW routine will issue a frame request strobe to fill the 10K memory and loop until the status of the memory is ready as shown in Figure 4. Instructions 27 through 37 calculate the mean value of the data within the minimum gate. When this is compared to the "nominal" value of seven in this case (instructions 38 through 48), various flags are set to track either a "black" or "white" target. This nominal value does not need to be fixed as it is here, but could be set by an automatic gain control in an optimum situation. Instruction 49 reinitializes the I, J, K, and L micro registers destroyed during the mean value and compare calculations (START routine, Figure 5). Instructions 50 through 53 set up the bias and gain latches which decide the amplitude

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and bias point in the video that is to be digitized coming from the CCD array. Instructions 55 and 59 set the color of the tracking gate depending upon what contrast target will be tracked.

Block No. 3 in Figure 1 is represented by a FRAMEW instruction (sequence No. 57). Instructions 54 through 61 represent block No. 4 in Figure 1.

Instructions 62 through 73 represent block No. 5 in Figure 1. The MEAN instruction takes the digitized data within the tracking gate and calculates the mean value as shown in Figure 6.

Instructions 74, 75, and 76 represent block No. 6 in Figure 1. The EGATES instruction sets the size of the edge gates shown in Figure 2. It also sets the target flag if the macro code mean value calculation found the mean to be less than seven as shown in Figure 7.

Instructions 77 through 99 represent block No. 7 in Figure 1. The CNTRD instruction calculates the centroid of the target within the tracking gate as shown in Figure 8.

Instructions 100 through 122 represent block No. 8 in Figure 1. NGATEA and NGATEC calculate NX and NY, respectively.

$NX = TAXG - AXG/2 + 4\ YS$

$NY = TAYG - AYG/2 + 4\ XS$

TAXG is the target area in X gate

TAYG is the target area in Y gate

AXG is the total area of X gate

AYG is the total area of Y gate

XS is the length of gate in X direction

YS is the length of gate in Y direction

NGATEB and NGATEL calculate I, K and J, L, respectively.

$DX = NX/(4\ YS)$

$DY = NY/(4\ XS)$

$DELXX = -\left(\dfrac{XS}{2} + DX\right)$

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I = X beginning of gate = DELXX + CX

K = X end of gate = CX - DELXX

$$DELYY = -\left(\frac{YS}{2} + DY\right)$$

J = Y beginning of gate = DELYY + CY

L = Y end of gate = CY - DELYY

CX = target centroid in X direction

CY = target centroid in Y direction

A detailed calculation of the new gate is shown in Figures 9 through 12.

III.   CONCLUSIONS

The current optical contrast variable gate centroid tracker is now undergoing several stages of optimization. This has been implemented and is useful in locking onto and tracking targets at long ranges; however, it does have the same limitations as other contrast trackers, i.e., a well bounded "patch" of contrast is necessary to track properly.

5
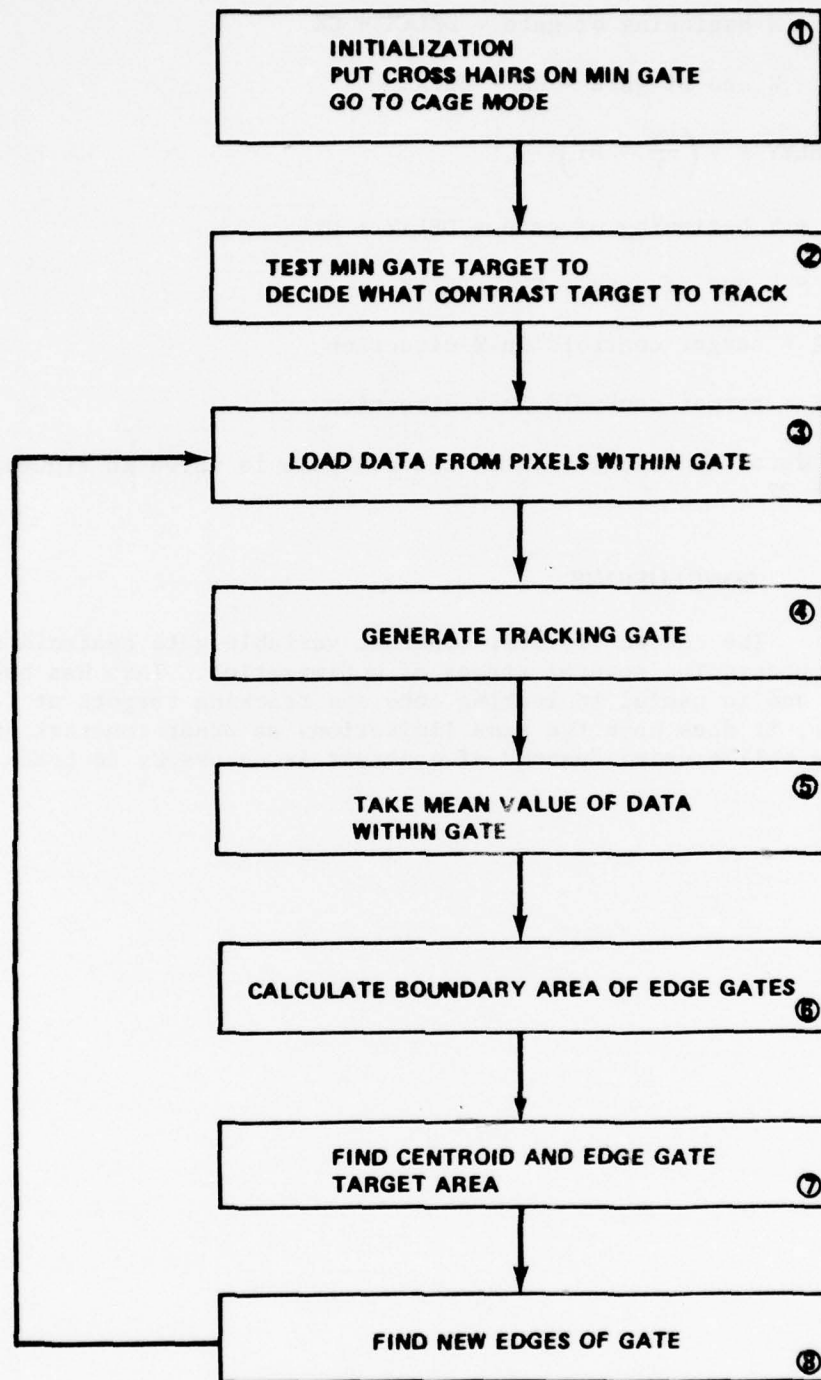
Figure 1. Main tracking loop.

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MACRO CALLING INSTRUCTION

START INIT

INITIALIZE I, J, K, AND L

LOAD DATA FROM   INIT+0 AND STORE IN I
INIT+1 AND STORE IN J
INIT+2 AND STORE IN K
INIT+3 AND STORE IN L

RETURN

I, J, K, AND L ARE REGISTERS IN THE INTEL 3000
CENTRAL PROCESSING UNIT.
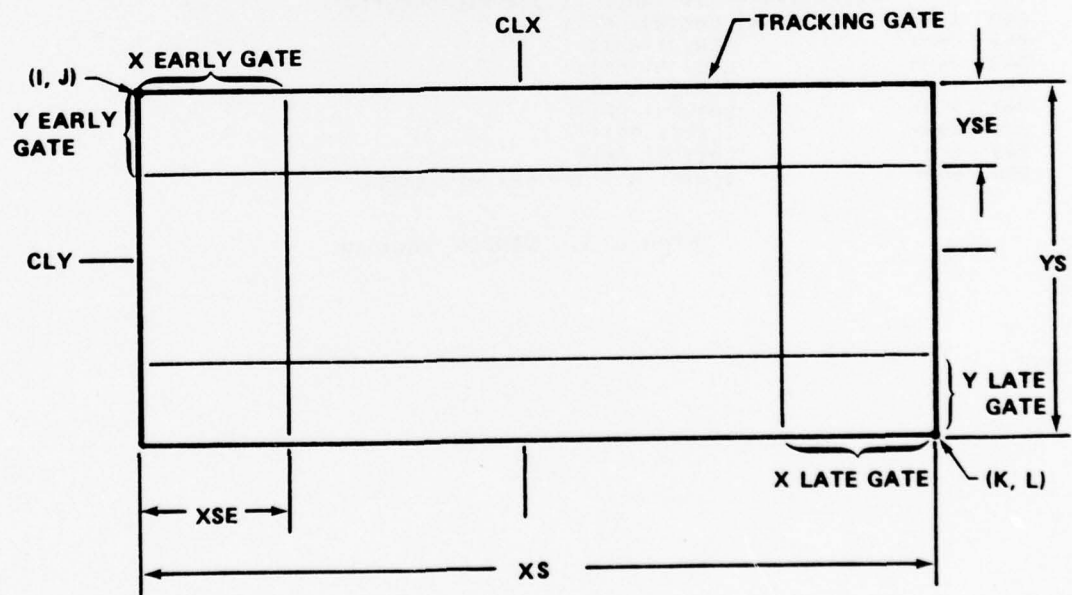
Figure 2. START routine for minimum gate.

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MACRO CALLING INSTRUCTION

WINDOW

LOAD WINDOW LATCHES
TO PUT OUT GATE.

LOAD LATCH (0) WITH J (COLUMN LEFT)
LOAD LATCH (1) WITH L (COLUMN RIGHT)
LOAD LATCH (2) WITH I (ROW UP)
LOAD LATCH (3) WITH K (ROW DOWN)

RETURN

```
242  /*      WINDOW-----(VARIABLE WINDOW MICROROUTINE)           */
243  13H!      WINDOW! LMI(R9) FF1:
244  23H!              ILR(J) ROT:
245  33H!              LMI(R9) FF1:
246  43H!              ILR(L) ROT:
247  53H!              LMI(R9) FF1:
248  63H!              ILR(I) ROT:
249  6CH!              LMI(R9) FF1:
250  63H!              ILR(K) ROT I7R(FETCH) PAGE1:
```

Figure 3. WINDOW routine.

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MACRO CALLING INSTRUCTION

FRAMEW


```
SET
STROBE        }   LOAD 10K CCD
BIT               MEMORY


LOAD IBUS
IN
MICRO
ACCUMULATOR


        NO    IS
              SIGN BIT
              SET

                     YES

              RETURN
```
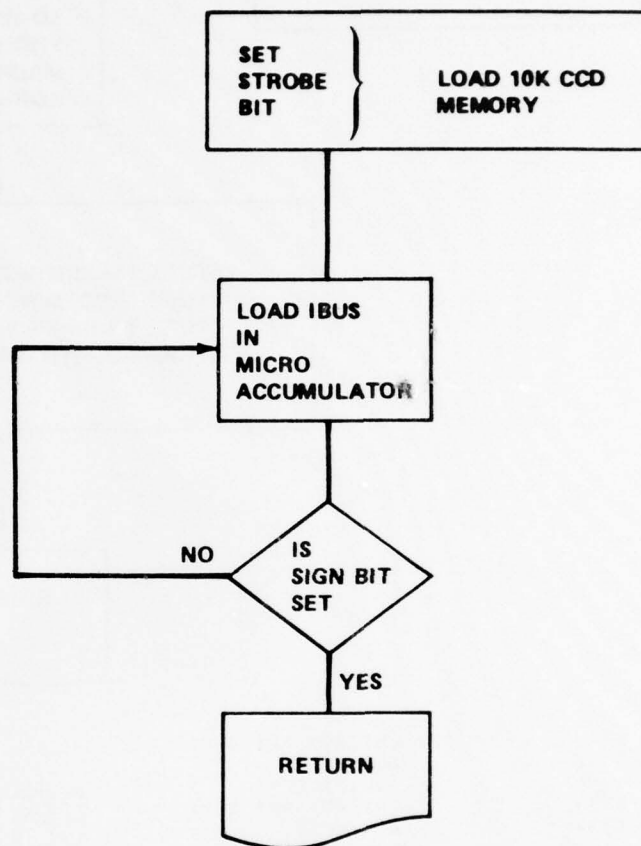
NOTE: THE SIGN BIT OF THE IBUS IS THE
      STATUS READY FLAG FOR THE CCD 10K MEMORY

```
251  1AH!     FRAME!  NOP(RB)  STROBE2:
252  1AAH!    WAT!    NOP(RB)  RIN:
253  1ACH!            LDI(AC)  FF1:
254  1ADH!            TZR(AC)  KB0000:
255  1AEH!            NOP(RB)  JFL(WAT+R)Y):
256  1ABH!    RDY!    NOP(RB)  JZR(FETCH) PAGE1:
```

Figure 4. FRAMEW routine.

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MACRO CALLING INSTRUCTION

START INIT

INIT OCT 61
OCT 61
OCT 63
OCT 63

LOAD DATA
FROM
MACRO
ADDRESSES

STORE FIRST WORD OF DATA IN I
STORE SECOND WORD OF DATA IN J
STORE THIRD WORD OF DATA IN K
STORE FOURTH WORD OF DATA IN L

RETURN

```
257  13H!        START! LMI(R9) FF1 RRM:
258  3H!                ACM(AC):
253  3DH!               SDR(I) FF1:
260  10H!               LMI(R9) FF1 RRM:
261  12H!               ACM(AC):
262  13H!               SDR(J) FF1:
263  14H!               LMI(R9) FF1 RRM:
264  15H!               ACM(AC):
265  16H!               SDR(K) FF1:
266  17H!               LMI(R9) RRM:
267  18H!               ACM(AC):
269  19H!               SDR(L) FF1 172(FETCH) PAGE1:
```

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Figure 5. Reinitialization of I, J, K, and L.

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TOTAL = 0
M = 0

MEAN VALUE

OLDJ = J

ADDRESS = (I – 1) * 100 + (J – 1)

LOAD DATA
FROM
ADDRESS
AND ADD
TO TOTAL

M = M + 1
J = J + 1

IS
J.GE.L
?

NO

ADDRESS =
ADDRESS + 1

YES

J = OLD J
I = I + 1

NO

IS
I.GE.K
?

YES

STORE
ELEMENT
COUNT IN
MACRO
MEMORY

STORE
TOTAL IN
MACRO
ACCUMULATOR

RETURN
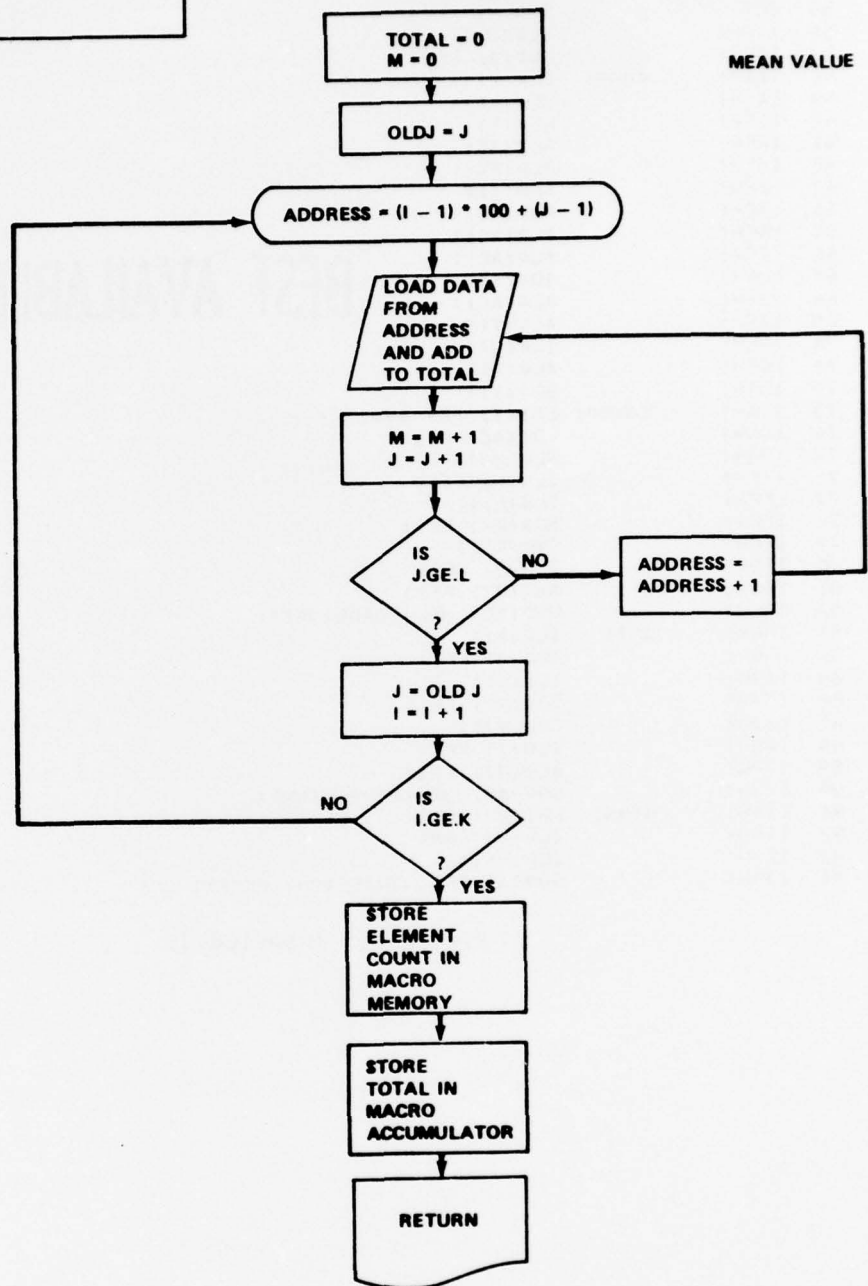
Figure 6.   Calculation of mean value.

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```
52  /*       CALCULATE MEAN VALUE FOR 100 BY 100 ARRAY   BEING DIGITIZED   */
53  114!      MEAN!  CLA(AC);
54  21H!              SDR(R6) FF1;
55  2CH!              SDR(M) FF1;
56  1DCH!             ILP(J);
57  11CH!             SDR(A) FF1;
58  11A4!     ADDR!  ILR(I);
59  110H!             DCA(AC);
60  11FH!             CLA(T);
61  12FH!             ALR(AC);
62  13FH!             ALR(AC);
63  14FH!             ALR(T);
64  15FH!             ALR(AC);
65  16FH!             ALP(AC);
66  17FH!             ALP(AC);
67  18FH!             ADP(T);
68  19FH!             ALR(AC);
69  1AFH!             ALR(T);
70  1BFH!             ILR(J);
71  1CFH!             ALP(T);
72  1DFH!             SDR(T);
73  1DA4!     LOADD! LMI(T) FF1 RRM;
74  1DDH!             LDI(AC) FF1;
75  1FDH!             ALR(R6);
76  1FFH!             ILR(M) FF1;
77  1FFH!             ILR(L);
78  1EFH!             SDR(R7) FF1;
79  1FEH!             CMR(R7);
80  1EDH!             ILR(J) FF1;
81  1ECH!             ALP(R7) FF1;
82  1DCH!             NOP(AC) JFL(LOADD.JGT);
83  1DBH!     JGT!   ILR(A);
84  1D9H!             SDR(J) FF1;
85  179H!             ILP(K);
86  169H!             SDR(R7) FF1;
87  159H!             CMR(R7);
88  149H!             ILP(I) FF1;
89  139H!             ALR(R7) FF1;
90  129H!             NOP(AC) JFL(ADDR.RTNN);
91  11HH!     RTNN!  LMI(R9) FF1;
92  11BH!             ILR(M) RWM;
93  12BH!             ILR(R6);
94  13HH!             SDR(A) FF1 JZR(FETCH) PAGE1;
```

Figure 6.   (Concluded).

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BOUNDARY AREA
OF EDGE GATES

$\Delta X = K - I$

$XG = \dfrac{\Delta x}{4}$

IS XG.EQ.O ?

YES → XG = 1

NO

$\Delta y = L - J$

$YG = \dfrac{\Delta y}{4}$

IS YG.EQ.O ?

YES → YG = 1

YEEG = J + YG
YBLG = L − YG
XEEG = I + XG
XBLG = K − XG

IS TARGET BLACK?

YES → 1 → ZFLG

NO → MEAN = − MEAN

RETURN
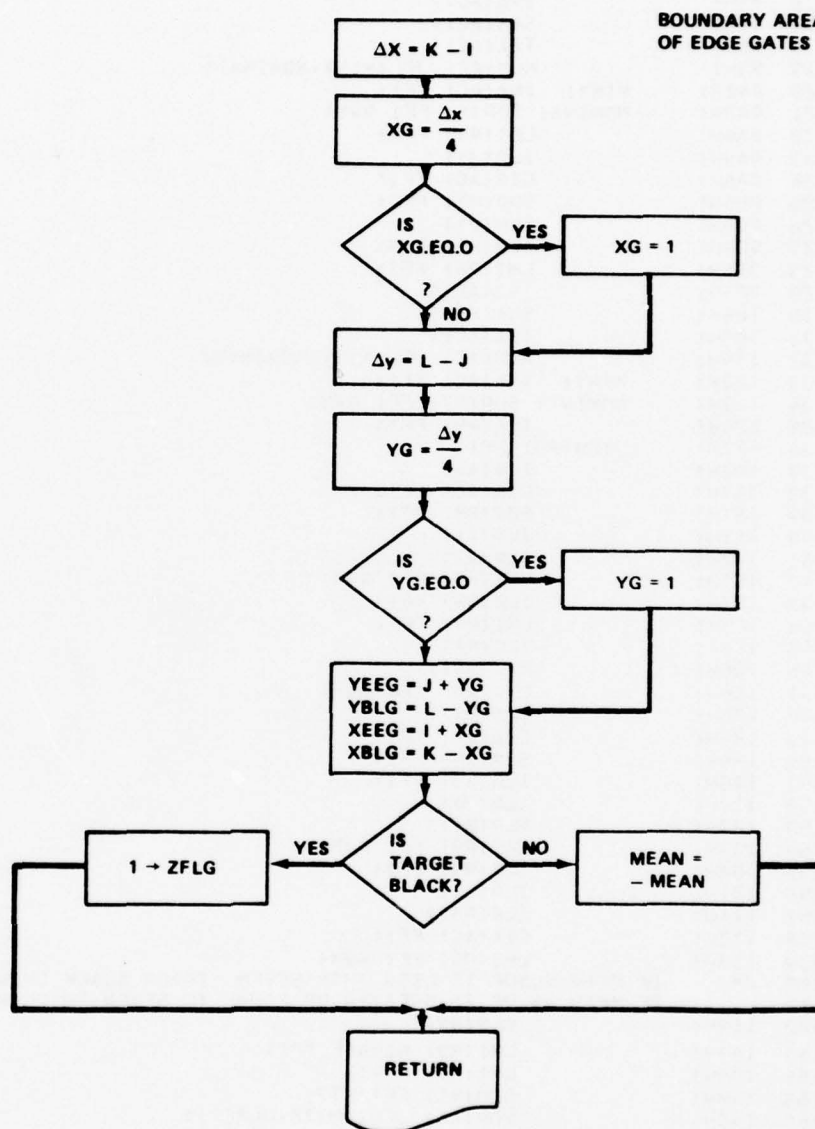
Figure 7. Setting of target flag when macro code mean value is less than seven.

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```
105  /*        CALCULATE BOUNDARY AREA OF EDGE GATES       */
106  14H!        EGATES! LMI(P) FF1 RRM:
107  24H!              ACM(AC):
108  34H!              SDR(R6) FF1:
109  44H!              LMI(R9) FF1:
110  54H!              ILR(I):
111  64H!              CIA(AC) FF1:
112  74H!              SDR(R7) FF1:
113  84H!              ILR(K):
114  854!              ALR(R7) RWM:
115  86H!              LMI(R6) FF1:
116  87H!              SRA(AC):
117  97H!              SRA(AC):
118  96H!              TZA(AC):
119  95H!              NOP(AC) JFL(MINX,NOMINX):
120  0A2H!      MINX!  INA(AC) FF1:
121  0A3H!      NOMINX! SDR(A) FF1 RWM:
122  0A4H!              LMI(R9) FF1:
123  0A5H!              ILR(J):
124  0A6H!              CIA(AC) FF1:
125  0B6H!              SDR(R7) FF1:
126  0C6H!              ILR(L):
127  0D6H!              ALR(R7) RWM:
128  0E6H!              LMI(R6) FF1:
129  0F6H!              SRA(AC):
130  106H!              SRA(AC):
131  105H!              TZA(AC):
132  115H!              NOP(AC) JFL(MINY,NOMINY):
133  122H!      MINY!  INA(AC) FF1:
134  123H!      NOMINY! SDR(R7) FF1 RWM:
135  124H!              ILR(R9) FF1:
136  127H!          TLR(R9) FF1:
137  167H!              ILR(A):
138  1A7H!              CIA(AC) FF1:
139  1B7H!              SDR(R8) FF1:
140  1C7H!              ILR(I):
141  1D7H!              ALR(A):
142  1E7H!              LMI(R9) FF1 RWM:
143  1F7H!              ILR(R9) FF1:
144  1F6H!              LMI(R9) FF1:
145  1E6H!              ILR(K):
146  1D6H!              ALR(R8):
147  1C6H!              CIA(AC) FF1 RWM:
148  1B6H!              ILR(R7):
149  1A6H!              CIA(AC) FF1:
150  156H!              SDR(R8) FF1:
151  116H!              ILR(R9) FF1:
152  117H!              ILR(J):
153  107H!              ALR(R7):
154  103H!              LMI(R9) FF1 RWM:
155  102H!              ILR(R9) FF1:
156  101H!              ILR(L):
157  111H!              ALR(R8):
158  112H!              CIA(AC) FF1:
159  113H!              LMI(R9) FF1 RWM:
160  /*      IF MEAN VLAUE IS LESS THAN SEVEN  TRACK BLACK ON WHITE
161          IF MEAN VALUE IS GREATER OR EQUAL TO SEVEN TRACK WHITE ON BLACK*/
162  119H!              CLR(R9):
163  109H!              LMI(R9) K0000F FF1:
164  109H!              LMI(R9) RRM:
165  148H!              ACM(AC) FF1 STZ:
166  14CH!              NOP(AC) JFL(WHITE,BLACK):
167  124H!      WHITE! CLR(R9):
168  10AH!              LMI(R9) K00005 RRM:
169  10BH!              LCM(AC):
170  10FH!              INA(AC) FF1 RWM PAGE1 JZR(FETCH):
171  12BH!      BLACK! NOP(AC) PAGE1 JZR(FETCH):
```

Figure 7. (Concluded).

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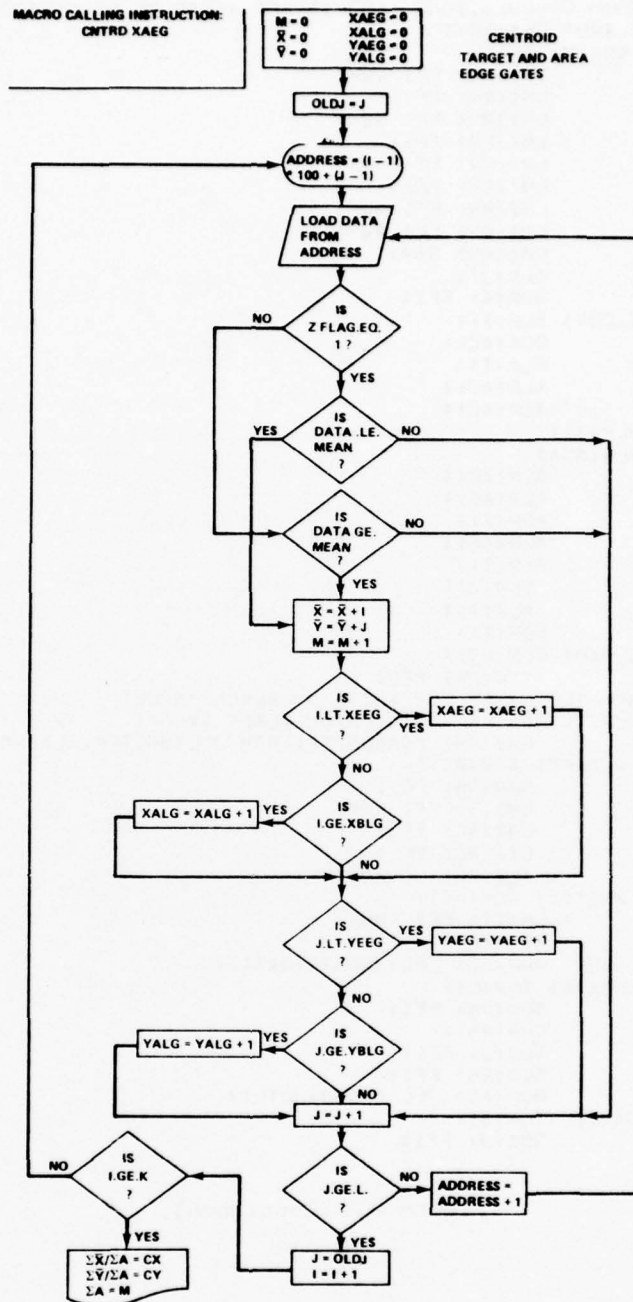
Figure 8. CNTRD calculation of target centroid within tracking gate.

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```
273   /*       CENTROID CALCULATIONS  AND TARGET AREAS OF EDGE GATES            */
274   10H!        CNTRO! CLA(AC);
275   00H!          SDR(M) FF1;
276   20H!              LMI(R9) FF1 RWM;
277   30H!              LMI(R9) FF1;
278   40H!              LMI(R9) FF1 RWM;
279   50H!              LMI(R9) FF1;
280   60H!              LMI(R9) FF1 RWM;
281   70H!              LMI(R9) FF1;
282   80H!              LMI(R9) FF1 RWM;
283   90H!              LMI(R9) FF1 RWM;
284   0A0H!             LMI(R9) RWM;
285   080H!             ILR(J);
286   0C0H!             SDR(A) FF1;
287   0C2H!        CADDR! ILR(I);
288   0C4H!             DCA(AC);
289   0D4H!             CLA(T);
290   0D0H!             ALR(AC);
291   0E0H!             ALR(AC);
292   0F0H!        ALR(T);
293   100H!       ALR(AC);
294   110H!             ALR(AC);
295   120H!             ALR(AC);
296   130H!             ADR(T);
297   140H!             ALR(AC);
298   150H!             ALR(T);
299   158H!             ILR(J);
300   168H!             ALR(T);
301   160H!             SDR(T);
302   162H!        CLOAD! CLR(R9);
303   156H!             T7R(R9) FF7;
304   /*        BRANCH TO WHITEE FOR WHITE ON BLACK TARGET
305             BRANCH TO BLACKK TO TRACK ON BLACK TARGET         */
306   16C4!            LMI(R9) K00005 FF1 RRM JFL(WHITEE,BLACKK);
307   178H!        BLACKK! ACM(AC);
308   17C4!             SDR(R6) FF1;
309   178H!             LMI(T) FF1 RRM;
310   188H!             LDI(AC) FF1;
311   198H!             CIA(AC) FF1;
312   1974!             ALR(R6) JCR(OVER);
313   17AH!         WHITEE! ACM(AC);
314   170H!             LMI(T) FF1 RRM;
315   180H!             AIA(AC);
316   1904!         OVER! NOP(AC) JFL(NODATA,DATA);
317   1924!        NODATA! ILR(L);
318   191H!             SDR(R6) FF1;
319   1A1H!             CMR(R6);
320   1A4H!             ILR(J) FF1;
321   194H!             ALR(R6) FF1;
322   1544!             NOP(AC) JFL(CLOAD,JGTL);
323   1634!         JGTL! ILR(A);
324   1654!             SDR(J) FF1;
```

Figure 8. (Continued).

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```
325  145H!              ILR(K):
326  144H!              SDR(R6) FF1:
327  104H!              CMR(R6):
328  0F4H!              ILR(I) FF1:
329  0E4H!              ALR(R6) FF1:
330  0A4H!              NOP(AC) JFL(CADDR,ENDC):
331  193H!      DATA!   ILR(R9):
332  195H!              SDR(R6)FF1:
333  1A5H!              LMI(R6) K00009:
334  1A0H!      ILR(I):
335  180H!              LMI(R6) FF1 RRM:
336  1C0H!              AMA(AC) RWM:
337  1D0H!              ILR(J):
338  1E0H!              LMI(R6) RRM:
339  1F0H!              AMA(AC) RWM:
340  1F5H!              ILR(M) FF1:
341  1E5H!              ILR(I):
342  1D5H!              CIA(AC):
343  104H!              LMI(R9) FF1 RRM:
344  1C4H!              AMA(AC):
345  1C5H!              NOP(AC) JFL(NXEEG,XEEG):
346  1B3H!      XEEG!   LMI(R9) FF1 RRM:
347  1B4H!              ACM(AC) FF1 RWM JCC(NXBLG2):
348  1B2H!      NXFFG!  ILR(R9) FF1:
349  1B1H!              ILR(I):
350  1A14!              LMI(R9) FF1 RRM:
351  171H!              AMA(AC):
352  161H!              NOP(AC) JFL(NXBLG,XBLG):
353  173H!      XBLG!   LMI(R9) FF1 RRM:
354  175H!              ACM(AC) FF1 RWM JCR(NXBL):
355  174H!      NXBLG2! ILR(R9) FF1:
356  172H!      NXBLG!  ILR(R9) FF1:
357  177H!      NXBL!   ILR(J):
358  137H!              CIA(AC):
359  136H!              LMI(R9) FF1 RRM:
360  135H!              AMA(AC):
361  134H!              NOP(AC) JFL(NYEEG,YEEG):
362  143H!      YEEG!   LMI(R9) FF1 RRM:
363  146H!              ACM(AC) FF1 RWM:
364  196H!              NOP(A) JCR(NODATA):
365  142H!      NYEEG!  ILR(R9) FF1:
366  147H!              ILR(J):
367  157H!              LMI(R9) FF1 RRM:
368  187H!              AMA(AC):
369  184H!              NOP(AC) JFL(NODAT,YBLG):
370  183H!      YBLG!   LMI(R9) FF1 RRM:
371  185H!              ACM(AC) FF1 RWM JCR(NODAT):
372  0C3H!      ENDC!   CLR(R9):
373  0C5H!              LMI(R9) K00004:
374  0E5H!              ILR(M) RWM PAGE1 JZR(FETCH):
375  182H!      NODAT!  NOP(A) JCC(NODATA):
```

Figure 8. (Concluded).

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CALCULATE DX

$$TAXG = XAEG + XALG$$

$$NX = TAXG - \frac{AXG}{2} + 4YS$$

STORE NX
IN
MACRO
ACCUMULATOR

STORE 4 YS
IN
MACRO ADDRESS
AXGH

RETURN

```
172   /*        NGATEA NGATEB NGATEC AND NGATEL CALCULATE EDGES OF THE GATE
173             AND THE NEW I J K L                        */
174   15H!      NGATEA! LMI(R9) RRM:
175   25H!              ACM(AC):
176   35H!              CIA(AC) FF1:
177   45H!              SDR(R6) FF1:
178   55H!              CLR(R7):
179   65H!              LMI(R7) K00007:
180   75H!              LMI(R7) FF1 RRM:
181   0B5H!             ACM(AC):
182   0BCH!             LMI(R7) FF1:
183   0DCH!             LMI(R7) RRM:
184   0DDH!             AMA(AC):
185   0CDH!             ADR(R6):
186   0BDH!             CLR(R7):
187   0ADH!             LMI(R7) K00003:
188   9DH!              LMI(R7) RRM:
189   8DH!              ACM(AC):
190   8CH!              ALR(AC):
191   9CH!              ALR(AC):
192   0ACH!             LMI(R9) FF1 RWM:
193   0CCH!             ALR(R6):
194   0CEH!             SDR(A) FF1 17R(FETCH) PAGE1:
```

Figure 9. New gate calculation of DX.

18

MACRO CALLING INSTRUCTION

NGATEB	DELX
ADR	CX

CALCULATE NEW I AND K
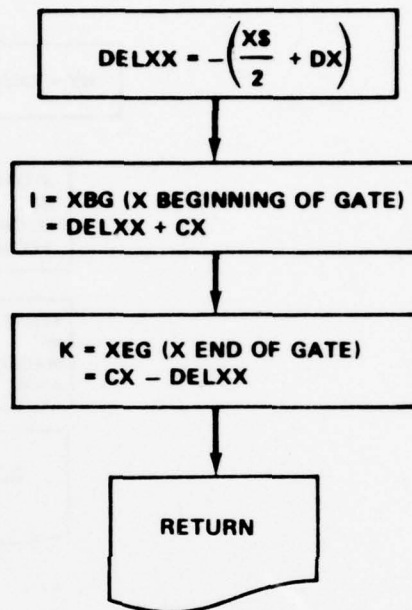
$$DELXX = -\left(\frac{XS}{2} + DX\right)$$

I = XBG (X BEGINNING OF GATE)
= DELXX + CX

K = XEG (X END OF GATE)
= CX − DELXX

RETURN

```
195  16H!      NGATEB! LMI(R9) RRM:
196  26H!              ACM(AC):
197  36H!              SRA(AC):
198  46H!              ALR(A):
199  56H!              SDR(A) FF1:
200  66H!              CIA(AC) FF1:
201  76H!              LMI(P) FF1 RRM:
202  79H!              LMM(T) RRM:
203  89H!              AMA(AC):
204  99H!              SDR(I) FF1:
205  0A9H!             ILR(A) RRM:
206  0B9H!             AMA(AC):
207  0C9H!             SDR(K) FF1 J7R(FETCH) PAGE1:
```

Figure 10. New gate calculation of I and K.

19

MACRO CALLING INSTRUCTION

NGATEC AYGH

CALCULATE DY
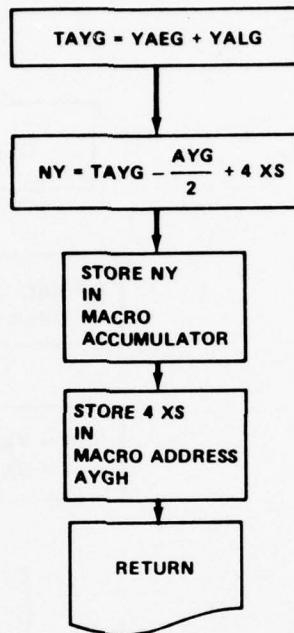
$$TAYG = YAEG + YALG$$

$$NY = TAYG - \frac{AYG}{2} + 4\ XS$$

STORE NY
IN
MACRO
ACCUMULATOR

STORE 4 XS
IN
MACRO ADDRESS
AYGH

RETURN

```
208   17H!          NGATEC! LMI(R9) RRM;
209   27H!                  ACM(AC);
210   37H!                  CIA(AC) FF1;
211   47H!                  SDR(R6) FF1;
212   57H!                  CLR(R7);
213   67H!                  LMI(R7) K0000B;
214   77H!                  LMI(R7) FF1 RRM;
215   0A7H!                 ACM(AC);
216   0B7H!                 LMI(R7) FF1;
217   0C7H!                 LMI(R7) RRM;
218   0D7H!                 AMA(AC);
219   0E7H!                 ADR(R6);
220   0F7H!                 CLR(R7);
221   0F8H!                 LMI(R7) K00002;
222   0F9H!                 LMI(R7) RRM;
223   0FCH!                 ACM(AC);
224   0FDH!                 ALR(AC);
225   0ED4!                 ALR(AC);
226   0FC4!                 LMI(R9) FF1 RWM;
227   0F94!                 ALR(R6);
228   0EB4!                 SDR(A) FF1 17R(FETCH) PAGE1;
```

Figure 11. New gate calculation of DY.

20

MACRO CALLING INSTRUCTION

NGATEL	DELY
ADR	CY
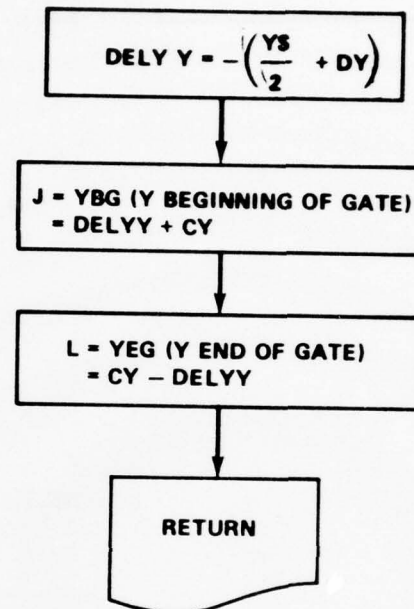
$$\text{DELY } Y = -\left(\frac{YS}{2} + DY\right)$$

J = YBG (Y BEGINNING OF GATE)
= DELYY + CY

L = YEG (Y END OF GATE)
= CY − DELYY

RETURN

```
229  18H!     NGATEL! LMI(R9) RRM:
230  2HH!             ACM(AC):
231  3HH!             SPA(AC):
232  4HH!             ALP(A):
233  5HH!             SDR(A) FF1:
234  6HH!             CIA(AC) FF1:
235  7HH!             LMI(P) FF1 RRM:
236  8HH!             LMM(T) RRM:
237  9HH!             AMA(AC):
238  0AHH!            SDR(J) FF1:
239  0BHH!            ILR(A) RRM:
240  0CHH!            AMA(AC):
241  0DHH!            SDR(L) FF1 JIR(FETCH) PAGE1:
```

Figure 12. New gate calculation of J and L.

21

MACRO CALLING INSTRUCTION
SAVEIJ I

MACRO CALLING INSTRUCTION
RESTIJ I

SAVEIJ

```
┌──────────────────┐
│ STORE            │
│ I AND J          │
│ REGISTERS IN     │
│ MACRO MEMORY     │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│                  │
│   RETURN         │
│                  │
└──────────────────┘
```

RESTIJ

```
┌──────────────────┐
│ LOAD I AND J     │
│ MICRO REGISTERS  │
│ FROM MACRO       │
│ MEMORY           │
└──────────────────┘
         │
         ▼
┌──────────────────┐
│                  │
│   RETURN         │
│                  │
└──────────────────┘
```
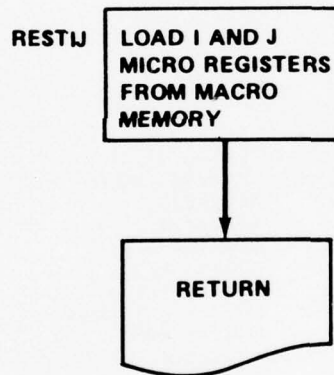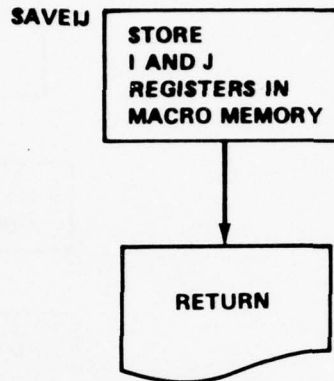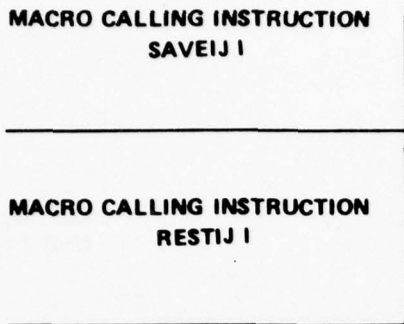
```
 95  12H!    SAVEIJ! LMI(R9) FF1:
 96  32H!            ILR(I) RWM:
 97  31H!            LMI(R9):
 98  41H!            ILR(J) RWM I7R(FETCH) PAGE1:


 99  13H!    RESTIJ! LMI(R9) FF1 RRM:
100  53H!            ACM(AC):
101  51H!            SDR(I) FF1:
102  61H!            LMI(R9) RRM:
103  71H!            ACM(AC):
104  81H!            SDR(J) FF1 I7R(FETCH) PAGE1:
```

Appendix A.
TRACKER MACRO CODE LISTING

23

```
  1: 00000 000001 010000              OCT    ?1
  2: 00001 000004 000000              OCT    1?0
  3: 00002 000001 000002     DELX     BSS    1
  4: 00003 000001 000003     DELY     BSS    1
  5: 00004 000001 000004     ASUM     BSS    1
  6: 00005 000001 000005     MEAN2    BSS    1
  7: 00006 000001 000006     XEEG     BSS    1
  8: 00007 000001 000007     XAEG     BSS    1
  9: 00010 000001 000010     XBLG2    BSS    1
 10: 00011 000001 000011     XALG     BSS    1
 11: 00012 000001 000012     YEEG     BSS    1
 12: 00013 000001 000013     YAEG     BSS    1
 13: 00014 000001 000014     YBLG2    BSS    1
 14: 00015 000001 000015     YALG     BSS    1
 15: 00016 000001 000016     XBAR     BSS    1
 16: 00017 000001 000017     YBAR     BSS    1
 17: 00020 000001 000020     BWF      BSS    1
                                      ABS    100
 19: 00100 125400 000262     START    INIT
 20: 00101 000000 000275              LA     TEN
 21: 00102 176400 060000              DO     6
 22: 00103 124400 000000              WINDOW
 23: 00104 037400 000000              P
 24: 00105 000000 000270              LA     SIX
 25: 00106 176400 060000              DO     6
 26: 00107 125000 000000              FRAMEW
 27: 00110 000000 000273              LA     THREE
 28: 00111 176400 060000              DO     6
 29: 00112 120400 000254              MEAN   ECOUNT
 30: 00113 174400 000000              EQ
 31: 00114 000000 000254              LA     ECOUNT
 32: 00115 032400 070000              ALS    7
 33: 00116 000400 000254              STA    ECOUNT
 34: 00117 030000 000000              CLR
 35: 00120 174400 000000              EQ
 36: 00121 003400 000254              B      ECOUNT
 37: 00122 033000 140000              LRS    14
 38: 00123 000000 000274              C      SEVEN
 39: 00124 072000 000000              SGE
 40: 00125 010000 000132              J      BLACK
 41: 00126 030000 000000              CLR
 42: 00127 000400 000374              STA    TARGET
 43: 00130 000400 000020              STA    BWF
 44: 00131 010000 000136              J      WHITE
 45: 00132 000000 000277     BLACK    LA     OONE
 46: 00133 000400 000020              STA    BWF
 47: 00134 000000 000276              LA     TWENTY
 48: 00135 000400 000374              STA    TARGET
 49: 00136 125400 000262     WHITE    START  INIT
 50: 00137 000000 000272              LA     T31
 •           SET GAIN TO MAX
 51: 00140 176400 050000              DO     5
 •           SET    OFFSET TO BLANKING LEVEL
 52: 00141 000000 000271              LA     BIAS
 53: 00142 176400 040000              DO     4
 •           STORE MODE LATCH FOR VIDEO
 54: 00143 000000 000270     START    LA     SIX
 55: 00144 004400 000374              OR     TARGET
 56: 00145 176400 060000              DO     6
```

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```
                 REQUEST FRAME AND WAIT TILL DATA READY
 57:  00146  125000  000000          FRAMEW
                 SET MODE LATCH FOR READ MODE
 58:  00147  026000  000266          LA      ONE
 59:  00150  004400  000374          OR      TARGET
 60:  00151  176400  060000          DO      6
 61:  00152  124400  000000          WINDOW
 62:  00153  121000  000255          SAVEIJ  I
 63:  00154  120400  000254          MEAN    ECOUNT
 64:  00155  174400  000000          EQ
 65:  00156  026000  000254          LA      ECOUNT
 66:  00157  032400  070000          ALS     7
 67:  00160  000400  000254          STA     ECOUNT
 68:  00161  030000  000000          CLR
 69:  00162  174400  000000          EQ
 70:  00163  003400  000254          D       ECOUNT
 71:  00164  033000  140000          LRS     14
 72:  00165  000400  000005          STA     MEAN2
 73:  00166  121400  000255          RESTIJ  I
 74:  00167  122000  000002          EGATES  DELX
 75:  00170  000000  000256          ADR     XG
 76:  00171  121000  000255          SAVEIJ  I
 77:  00172  120000  000007          CNTRD   XAEG
 78:  00173  026000  000004          LA      ASUM
 79:  00174  032400  070000          ALS     7
 80:  00175  060400  000004          STA     ASUM
 81:  00176  030000  000000          CLR
 82:  00177  174400  000000          EQ
 83:  00200  026000  000016          LA      YEAR
 84:  00201  003400  000004          D       ASUM
 85:  00202  033000  140000          LRS     14
 86:  00203  000400  000252          STA     CX
 87:  00204  026000  000017          LA      YEAR
 88:  00205  003400  000004          D       ASUM
 89:  00206  033000  140000          LRS     14
 90:  00207  000400  000253          STA     CY
 91:  00210  026000  000043          LA      DELY
 92:  00211  003600  000256          M       XG
 93:  00212  174400  000000          EQ
 94:  00213  000400  000257          STA     AXGH
 95:  00214  000000  000002          LA      DELX
 96:  00215  003000  000251          M       YG
 97:  00216  174400  000000          EQ
 98:  00217  000400  000260          STA     AYGH
 99:  00220  121400  000255          RESTIJ  I
100:  00221  122400  000257          NGATEA  AXGH
101:  00222  174400  000000          EQ
102:  00223  000000  000257          LA      AXGH
103:  00224  032400  040000          ALS     4
104:  00225  060400  000257          STA     AXGH
105:  00226  030000  000000          CLR
106:  00227  174400  000000          EQ
107:  00230  003400  000257          D       AXGH
108:  00231  032000  100000          ARS     18
109:  00232  123000  000002          NGATEB  DELX
110:  00233  000000  000252          ADR     CX
111:  00234  123400  000263          NGATEC  AYGH
112:  00235  174400  000000          EQ
113:  00236  000000  000264          LA      AYGH
114:  00237  032400  040000          ALS     4
115:  00240  060400  000264          STA     AYGH
116:  00241  030000  000000          CLR
```

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```
117: 77242 174400 000000              EQ
118: 00243 003400 000260         D    AYGH
119: 00244 032000 170000              ARS   10
120: 00245 124000 000003         NGATEL DELY
121: 00246 030000 000253         ADR   CY
122: 00247 010000 000143         J    START
123: 00250 030001 000250    XG   BSS   1
124: 00251 000001 000251    YG   BSS   1
125: 00252 030001 000252    CX   BSS   1
126: 00253 000001 000253    CY   BSS   1
127: 00254 000001 000254    ECOUNT BSS  1
128: 00255 000001 000255    I    BSS   1
129: 00256 000001 000256    J    BSS   1
130: 00257 000001 000257    AXGH BSS   1
131: 00260 000001 000260    AYGH BSS   1
132: 00261 000001 000261    AG2  BSS   1
133: 00262 000003 010000    INIT OCT   61
134: 00263 000003 010000         OCT   61
135: 00264 000003 030000         OCT   63
136: 00265 000003 030000         OCT   63
137: 00266 000000 010000    ONE  OCT   1
138: 00267 000000 020000    TWO  OCT   2
139: 00270 020000 060000    SIX  OCT   6
140: 00271 000000 060000    BIAS OCT   6
141: 00272 020000 110000    T31  OCT   31
142: 00273 000000 030003    THREE OCT  3
143: 00274 000000 070000    SEVEN OCT  7
144: 00275 000000 100000    TEN  OCT   10
145: 00276 000001 000000    TWENTY OCT 20
146: 00277 177777 177000    OONE OCT   3 77 77 77
147: 00300 000000 000300    XXA  BSS   12
148: 00312 000000 000312    XXB  BSS   12
149: 00324 000000 000324    YYA  BSS   12
150: 00336 000000 000336    YYB  BSS   12
151: 00350 000000 000350    YYC  BSS   12
152: 00362 000000 000362    DMP  BSS   12
153: 00374 000001 000374    TARGET BSS 1
154: 00375 060000 000000    G    OCT   1400000
```

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Appendix B.

TRACKER MICRO CODE LISTING

```
RECORD
NUMBER

    1
    2    KBUSS      FIELD  LENGTH=5   DEFAULT=0
    3                     MICROPS(KFFFFF=10101B    KFFFF4=10100B    K7FFFF=10011B
    4                            K80000=10010B    K00FFF=10001B    K00060=10000B
    5                            K0000F=01111B    K0000E=01110B    K0000D=01101B
    6                            K0000C=01100B    K0000B=01011B    K0000A=01010B
    7                            K00009=01001B    K00008=01000B    K00007=00111B
    8                            K00006=00110B    K00005=00101B    K00004=00100B
    9                            K00003=00011B    K00002=00010B    K00001=00001B
   10                            K00000=00000B);
   11    KBUSS      KBUS:
   12
   13    /* ALL MICROCODE IS ON PAGE2 WITH DEFAULT SET TO 00001 FOR OTHER */
   14    OTHER      FIELD  LENGTH=5   DEFAULT=00001B
   15                     MICROPS(STROBE=10000B  PAGE1=00000B  PAGE2=00001B
   16                            STROBE2=10001B);
   17
   18    /* DEFINITION OF BUS CONTROL FIELD           */
   19
   20    CBUS       FIELD  LENGTH=3           DEFAULT=0
   21                     MICROPS(NBO=000B    INH=001B    RMW=010B    CNB=011B
   22                            RIN=100B    ROT=101B    RRM=110B    RWM=111B);
   23
   24    /*      NBO      NOBUS OPERATION
   25            INH      INHIBIT CPE ARRAY
   26            RMW      READ-MODIFY-WRITE
   27            CNB      CPU NEEDS BUS
   28            RIN      REQUEST INPUT
   29            ROT      REQUEST OUTPUT
   30            RRM      REQUEST READ MEMORY
   31            RWM      REQUEST WRITE MEMORY
   32
   33            SET UP SYMBOLIC REPRESENTATION OF REGISTER DESIGNATIONS */
   34
   35    A          STRING 'R0':
   36    I          STRING 'R1':
   37    J          STRING 'R2':
   38    P          STRING 'R3':
   39    K          STRING 'R4':
   40    L          STRING 'R5':
   41    TEMP       STRING 'R6':
   42    TEMP2      STRING 'R7':
   43    M          STRING 'R8':
   44
   45    PAUSE      FIELD  LENGTH=1   DEFAULT=1
   46                     MICROPS(PP=0):
   47
   48
   49    OFH:       FETCH: NOP(A) JPR(CNTRD MEAN SAVEIJ RESTIJ EGATES NGATEA
   50                     NGATEB NGATEC NGATEL WINDOW FRAME START NOTC NOTD NOTE
   51                     NOTF):
   52    /*      CALCULATE MEAN VALUE FOR 100 BY 100 ARRAY   BEING DIGITIZED    */
   53    11H:       MEAN: CLA(AC):
   54    21H:             SDR(R6) FF1:
```

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RECORD
NUMBER

```
 55  2CH!              SDR(M) FF1:
 56  10CH!             ILR(J):
 57  11CH!             SDR(A) FF1:
 58  11AH!     ADDR!   ILR(I):
 59  11DH!             DCA(AC):
 60  11EH!             CLA(T):
 61  12EH!             ALR(AC):
 62  13EH!             ALR(AC):
 63  14EH!             ALR(T):
 64  15EH!             ALR(AC):
 65  16EH!             ALR(AC):
 66  17EH!             ALR(AC):
 67  18EH!             ADR(T):
 68  19EH!             ALR(AC):
 69  1AEH!             ALR(T):
 70  1BEH!             ILR(J):
 71  1CEH!             ALR(T):
 72  1DEH!             SDR(T):
 73  1DAH!     LOADD!  LMI(T) FF1 RRM:
 74  1DDH!             LDI(AC) FF1:
 75  1FDH!             ALR(R6):
 76  1FEH!             ILR(M) FF1:
 77  1FFH!             ILR(L):
 78  1EFH!             SDR(R7) FF1:
 79  1EEH!             CMR(R7):
 80  1EDH!             ILR(J) FF1:
 81  1ECH!             ALR(R7) FF1:
 82  1DCH!             NOP(AC) JFL(LOADD,JGT):
 83  1DBH!     JGT!    ILR(A):
 84  1D9H!             SDR(J) FF1:
 85  179H!             ILR(K):
 86  169H!             SDR(R7) FF1:
 87  159H!             CMR(R7):
 88  149H!             ILR(I) FF1:
 89  139H!             ALR(R7) FF1:
 90  129H!             NOP(AC) JFL(ADDR,RTNN):
 91  11BH!     RTNN!   LMI(R9) FF1:
 92  11AH!             ILR(M) RWM:
 93  128H!             ILR(R6):
 94  138H!             SDR(A) FF1 JZR(FETCH) PAGE1:
 95  12H!      SAVEIJ! LMI(R9) FF1:
 96  32H!              ILR(I) RWM:
 97  31H!              LMI(R9):
 98  41H!              ILR(J) RWM JZR(FETCH) PAGE1:
 99  13H!    · RESTIJ! LMI(R9) FF1 RRM:
100  53H!              ACM(AC):
101  51H!              SDR(I) FF1:
102  61H!              LMI(R9) RRM:
103  71H!              ACM(AC):
104  81H!              SDR(J) FF1 JZR(FETCH) PAGE1:
105  /*        CALCULATE BOUNDARY AREA OF EDGE GATES      */
106  14H!      EGATES! LMI(P) FF1 RRM:
107  24H!              ACM(AC):
108  34H!              SDR(R6) FF1:
```

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RECORD
NUMBER

```
109  44H!          LMI(R9) FF1:
110  54H!          ILR(I):
111  64H!          CIA(AC) FF1:
112  74H!          SDR(R7) FF1:
113  84H!          ILR(K):
114  85H!          ALR(R7) RWM:
115  86H!          LMI(R6) FF1:
116  87H!          SRA(AC):
117  97H!          SRA(AC):
118  96H!          TZA(AC):
119  95H!          NOP(AC) JFL(MINX,NOMINX):
120  0A2H!   MINX!  INA(AC) FF1:
121  0A3H!   NOMINX! SDR(A) FF1 RWM:
122  0A4H!          LMI(R9) FF1:
123  0A5H!          ILR(J):
124  0A6H!          CIA(AC) FF1:
125  0B6H!          SDR(R7) FF1:
126  0C6H!          ILR(L):
127  0D6H!          ALR(R7) RWM:
128  0E64!          LMI(R6) FF1:
129  0F6H!          SRA(AC):
130  106H!          SRA(AC):
131  105H!          TZA(AC):
132  115H!          NOP(AC) JFL(MINY,NOMINY):
133  122H!   MINY!  INA(AC) FF1:
134  123H!   NOMINY! SDR(R7) FF1 RWM:
135  124H!          ILR(R9) FF1:
136  127H!         ILR(R9) FF1:
137  167H!          ILR(A):
138  1A7H!          CIA(AC) FF1:
139  1B7H!          SDR(R8) FF1:
140  1C7H!          ILR(I):
141  1D7H!          ALR(A):
142  1E7H!          LMI(R9) FF1 RWM:
143  1F7H!          ILR(R9) FF1:
144  1F6H!          LMI(R9) FF1:
145  1E6H!          ILR(K):
146  1D6H!          ALR(R8):
147  1C6H!          CIA(AC) FF1 RWM:
148  1B6H!          ILR(R7):
149  1A6H!          CIA(AC) FF1:
150  156H!          SDR(R8) FF1:
151  116H!          ILR(R9) FF1:
152  117H!          ILR(J):
153  107H!          ALR(R7):
154  103H!          LMI(R9) FF1 RWM:
155  102H!          ILR(R9) FF1:
156  101H!          ILR(L):
157  111H!          ALR(R8):
158  112H!          CIA(AC) FF1:
159  113H!          LMI(R9) FF1 RWM:
160  /*    IF MEAN VLAUE IS LESS THAN SEVEN  TRACK BLACK ON WHITE
161        IF MEAN VALUE IS GREATER OR EQUAL TO SEVEN TRACK WHITE ON BLACK*/
162  119H!          CLR(R9):
```

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RECORD
NUMBER

```
163  109H!              LMI(R9) K0000F FF1:
164  108H!              LMI(R9) RRM:
165  148H!              ACM(AC) FF1 STZ:
166  14CH!              NOP(AC) JFL(WHITE,BLACK):
167  12AH!      WHITE! CLR(R9):
168  10AH!              LMI(R9) K00005 RRM:
169  108H!              LCM(AC):
170  10EH!              INA(AC) FF1 RWM PAGE1 J7R(FETCH):
171  128H!      BLACK! NOP(AC) PAGE1 JZR(FETCH):
172  /*          NGATEA NGATEB NGATEC AND NGATEL CALCULATE EDGES OF THE GATE
173              AND THE NEW I J K L                    */
174  15H!         NGATEA! LMI(R9) RRM:
175  25H!              ACM(AC):
176  35H!              CIA(AC) FF1:
177  45H!              SDR(R6) FF1:
178  55H!              CLR(R7):
179  65H!              LMI(R7) K00007:
180  75H!              LMI(R7) FF1 RRM:
181  085H!             ACM(AC):
182  08CH!             LMI(R7) FF1:
183  0DCH!             LMI(R7) RRM:
184  0DDH!             AMA(AC):
185  0CDH!             ADR(R6):
186  0BDH!             CLR(R7):
187  0ADH!             LMI(R7) K00003:
188  9DH!              LMI(R7) RRM:
189  8DH!              ACM(AC):
190  8CH!              ALR(AC):
191  9CH!              ALR(AC):
192  0ACH!             LMI(R9) FF1 RWM:
193  0CCH!             ALR(R6):
194  0CEH!             SDR(A) FF1 I7R(FETCH) PAGE1:
195  16H!         NGATEB! LMI(R9) RRM:
196  26H!              ACM(AC):
197  36H!              SRA(AC):
198  46H!              ALR(A):
199  56H!              SDR(A) FF1:
200  66H!              CIA(AC) FF1:
201  76H!              LMI(P) FF1 RRM:
202  79H!              LMM(T) RRM:
203  89H!              AMA(AC):
204  99H!              SDR(I) FF1:
205  0A9H!             ILR(A) RRM:
206  089H!             AMA(AC):
207  0C9H!             SDR(K) FF1 JZR(FETCH) PAGE1:
208  17H!         NGATEC! LMI(R9) RRM:
209  27H!              ACM(AC):
210  37H!              CIA(AC) FF1:
211  47H!              SDR(R6) FF1:
212  57H!              CLR(R7):
213  67H!              LMI(R7) K0000B:
214  77H!              LMI(R7) FF1 RRM:
215  0A7H!             ACM(AC):
216  087H!             LMI(R7) FF1:
```

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RECORD
NUMBER

```
217  0C74!              LMI(R7) RRM:
218  0D74!              AMA(AC):
219  0E74!              ADR(R6):
220  0F74!              CLR(R7):
221  0F84!              LMI(R7) K00002:
222  0F94!              LMI(R7) RRM:
223  0FC4!              ACM(AC):
224  0FD4!              ALR(AC):
225  0ED4!              ALR(AC):
225  0EC4!              LMI(R9) FF1 RWM:
227  0E94!              ALR(R6):
228  0E84!              SDR(A) FF1  JZR(FETCH) PAGE1:
229  18H!       NGATEL! LMI(R9) RRM:
230  28H!               ACM(AC):
231  38H!               SRA(AC):
232  48H!               ALR(A):
233  58H!               SDR(A) FF1:
234  68H!               CIA(AC) FF1:
235  78H!               LMI(P) FF1 RRM:
236  88H!               LMM(T) RRM:
237  98H!               AMA(AC):
238  0A84!              SDR(J) FF1:
239  0B84!              ILR(A) RRM:
240  0C84!              AMA(AC):
241  0D84!              SDR(L) FF1 JZR(FETCH) PAGE1:
242  /*        WINDOW-----(VARIABLE WINDOW MICROROUTINE)          */
243  19H!       WINDOW! LMI(R9) FF1:
244  29H!               ILR(J) ROT:
245  39H!               LMI(R9) FF1:
246  49H!               ILR(L) ROT:
247  59H!               LMI(R9) FF1:
248  69H!               ILR(I) ROT:
249  6CH!               LMI(R9) FF1:
250  6DH!               ILR(K) ROT JZR(FETCH) PAGE1:
251  1AH!       FRAME!  NOP(R8) STROBE2:
252  1AA4!      WAT!    NOP(R8) RIN:
253  1AC4!              LDI(AC) FF1:
254  1AD4!              TZR(AC) K80000:
255  1AF4!              NOP(R8) JFL(WAT,RDY):
256  1AB4!      RDY!    NOP(R8) JZR(FETCH) PAGE1:
257  1BH!       START!  LMI(R9) FF1 RRM:
258  3BH!               ACM(AC):
259  3DH!               SDR(I) FF1:
260  10D4!              LMI(R9) FF1 RRM:
261  12D4!              ACM(AC):
262  13D4!              SDR(J) FF1:
263  14D4!              LMI(R9) FF1 RRM:
264  15D4!              ACM(AC):
265  16D4!              SDR(K) FF1:
266  17D4!              LMI(R9) RRM:
267  18D4!              ACM(AC):
268  19D4!              SDR(L) FF1 JZR(FETCH) PAGE1:
269  1CH!       NOTC!   NOP(A) JZR(FETCH) PAGE1:
270  1D4!       NOTD!   NOP(A) JZR(FETCH) PAGE1:
```

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RECORD
NUMBER

```
271  1EH!      NOTE!   NOP(A) JZR(FETCH) PAGE1!
272  1FH!      NOTE!   NOP(A) JZR(FETCH) PAGE1!
273  /*      CENTROID CALCULATIONS  AND TARGET AREAS OF EDGE GATES        */
274  10H!      CNTRD! CLA(AC)!
275  00H!       SDR(M) FF1!
276  20H!            LMI(R9) FF1 RWM!
277  30H!            LMI(R9) FF1!
278  40H!            LMI(R9) FF1 RWM!
279  50H!            LMI(R9) FF1!
280  60H!            LMI(R9) FF1 RWM!
281  70H!            LMI(R9) FF1!
282  80H!            LMI(R9) FF1 RWM!
283  90H!            LMI(R9) FF1 RWM!
284  0A0H!           LMI(R9) RWM!
285  080H!           ILR(J)!
286  0C0H!           SDR(A) FF1!
287  0C2H!     CADDR! ILR(I)!
288  0C4H!           DCA(AC)!
289  0D4H!           CLA(T)!
290  0D0H!           ALR(AC)!
291  0E0H!           ALR(AC)!
292  0F0H!     ALR(T)!
293  100H!     ALR(AC)!
294  110H!           ALR(AC)!
295  120H!           ALR(AC)!
296  130H!           ADR(T)!
297  140H!           ALR(AC)!
298  150H!           ALR(T)!
299  158H!           ILR(J)!
300  168H!           ALR(T)!
301  160H!           SDR(T)!
302  162H!     CLOAD! CLR(R9)!
303  166H!           TZR(R9) FF7!
304  /*      BRANCH TO WHITEE FOR WHITE ON BLACK TARGET
305          BRANCH TO BLACKK TO TRACK ON BLACK TARGET       */
306  16CH!           LMI(R9) K00005 FF1 RRM JFL(WHITEE,BLACKK)!
307  17BH!     BLACKK! ACM(AC)!
308  17CH!           SDR(R6) FF1!
309  178H!           LMI(T) FF1 RRM!
310  188H!           LDI(AC) FF1!
311  198H!           CIA(AC) FF1!
312  197H!           ALR(R6) JCR(OVER)!
313  17AH!     WHITEE! ACM(AC)!
314  170H!           LMI(T) FF1 RRM!
315  180H!           AIA(AC)!
316  190H!      OVER! NOP(AC) JFL(NODATA,DATA)!
317  192H!     NODATA! ILR(L)!
318  191H!           SDR(R6) FF1!
319  1A1H!           CMR(R6)!
320  1A4H!           ILR(J) FF1!
321  194H!           ALR(R6) FF1!
322  154H!           NOP(AC) JFL(CLOAD,JGTL)!
323  163H!     JGTL!  ILR(A)!
324  165H!           SDR(J) FF1!
```

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RECORD
NUMBER

```
325  145H!              ILR(K)!
326  144H!              SDR(R6) FF1!
327  104H!              CMR(R6)!
328  0F4H!              ILR(I) FF1!
329  0E4H!              ALR(R6) FF1!
330  0A4H!              NOP(AC) JFL(CADDR,ENDC)!
331  193H!       DATA!  ILR(R9)!
332  195H!              SDR(R6)FF1!
333  1A5H!              LMI(R6) K00008!
334  1A0H!       ILR(I)!
335  1B0H!              LMI(R6) FF1 RRM!
336  1C0H!              AMA(AC) RWM!
337  100H!              ILR(J)!
338  1E0H!              LMI(R6) RRM!
339  1F0H!              AMA(AC) RWM!
340  1F5H!              ILR(M) FF1!
341  1E5H!              ILR(I)!
342  1D5H!              CIA(AC)!
343  1D4H!              LMI(R9) FF1 RRM!
344  1C4H!              AMA(AC)!
345  1C5H!              NOP(AC) JFL(NXEEG,XEEG)!
346  1B3H!       XEEG!  LMI(R9) FF1 RRM!
347  1B4H!              ACM(AC) FF1 RWM JCC(NXBLG2)!
348  1B2H!       NXEEG! ILR(R9) FF1!
349  1B1H!              ILR(I)!
350  181H!              LMI(R9) FF1 RRM!
351  171H!              AMA(AC)!
352  161H!              NOP(AC) JFL(NXBLG,XBLG)!
353  173H!       XBLG!  LMI(R9) FF1 RRM!
354  175H!              ACM(AC) FF1 RWM JCR(NXBL)!
355  174H!       NXBLG2! ILR(R9) FF1!
356  172H!       NXBLG! ILR(R9) FF1!
357  177H!       NXBL!  ILR(J)!
358  137H!              CIA(AC)!
359  136H!              LMI(R9) FF1 RRM!
360  135H!              AMA(AC)!
361  134H!              NOP(AC) JFL(NYEEG,YEEG)!
362  143H!       YEEG!  LMI(R9) FF1 RRM!
363  146H!              ACM(AC) FF1 RWM!
364  196H!              NOP(A) JCR(NODATA)!
365  142H!       NYEEG! ILR(R9) FF1!
366  147H!              ILR(J)!
367  157H!              LMI(R9) FF1 RRM!
368  187H!              AMA(AC)!
369  184H!              NOP(AC) JFL(NODAT,YBLG)!
370  183H!       YBLG!  LMI(R9) FF1 RRM!
371  185H!              ACM(AC) FF1 RWM JCR(NODAT)!
372  0C3H!       ENDC!  CLR(R9)!
373  0C5H!              LMI(R9) K00004!
374  0E5H!              ILR(M) RWM PAGE1 JZR(FETCH)!
375  182H!       NODAT! NOP(A) JCC(NODATA)!
376  EOF
```

NO PROGRAM ERRORS

END OF PROGRAM

MICROPROGRAM MEMORY IMAGE

	0H	1H	2H	3H	4H	5H	6H	7H
000H	JCC 0020H 275 1							
001H	JCC 0000H 274 1	JCC 0021H 53 1	JCC 0032H 95 1	JCC 0053H 99 1	JCC 0024H 106 1	JCC 0025H 174 1	JCC 0026H 195 1	JCC 0027H 208 1
002H	JCC 0030H 276 1	JCR 002CH 54 1			JCC 0034H 107 1	JCC 0035H 175 1	JCC 0036H 196 1	JCC 0037H 209 1
003H	JCC 0040H 277 1	JCC 0041H 97 1	JCR 0031H 96 1		JCC 0044H 108 1	JCC 0045H 176 1	JCC 0046H 197 1	JCC 0047H 210 1
004H	JCC 0050H 278 1	JZR 000FH 98 1			JCC 0054H 109 1	JCC 0055H 177 1	JCC 0056H 198 1	JCC 0057H 211 1
005H	JCC 0060H 279 1	JCC 0061H 101 1		JCR 0051H 100 1	JCC 0064H 110 1	JCC 0065H 178 1	JCC 0066H 199 1	JCC 0067H 212 1
006H	JCC 0070H 280 1	JCC 0071H 102 1			JCC 0074H 111 1	JCC 0075H 179 1	JCC 0076H 200 1	JCC 0077H 213 1
007H	JCC 0080H 281 1	JCC 0081H 103 1			JCC 0084H 112 1	JCC 0085H 180 1	JCR 0079H 201 1	JCC 00A7H 214 1

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MICROPROGRAM MEMORY IMAGE

	0H	1H	2H	3H	4H	5H	6H	7H
	JCC	JZR			JCR	JCR	JCR	JCC
	0090H	000FH			0085H	00A6H	0087H	0097H
008H								
	282	104			113	114	115	116
	1	1			1	1	1	1
	JCC					JFL	JCR	JCR
	00A0H					00A2H	0095H	0096H
009H								
	283					119	118	117
	1					1	1	1
	JCC		JCR	JCR	JCR	JCR	JCC	JCC
	00B0H		00A3H	00A4H	00A5H	00A6H	00B6H	00B7H
00AH								
	284		120	121	122	123	124	215
	1		1	2	1	1	1	1
	JCC				JFL	JCR	JCC	JCC
	00C0H				00C2H	00BCH	00C6H	00C7H
00BH								
	285				330	181	125	216
	1				1	1	1	1
	JCR		JCR	JCR	JCC	JCC	JCC	JCC
	00C2H		00C4H	00C5H	00D4H	00E5H	00D6H	00D7H
00CH								
	286		287	372	288	373	126	217
	1		2	1	1	1	1	1
	JCC				JCR		JCC	JCC
	00E0H				00D0H		00E6H	00E7H
00DH								
	290				289		127	218
	1				1		1	1
	JCC				JCC	JZR	JCC	JCC
	00F0H				00B4H	000FH	00F6H	00F7H
00EH								
	291				329	374	128	219
	1				1	1	1	1
	JCC				JCC		JCC	JCR
	0100H				00E4H		0106H	00F8H
00FH								
	292				328		129	220
	1				1		1	1

MICROPROGRAM MEMORY IMAGE

	0H	1H	2H	3H	4H	5H	6H	7H
	JCC	JCC	JCR	JCR	JCC	JCC	JCR	JCR
	0110H	0111H	0101H	0102H	00F4H	0115H	0105H	0103H
010H	293	156	155	154	327	131	130	153
	1	1	1	1	1	1	1	1
	JCC	JCR	JCR	JCR		JFL	JCR	JCC
	0120H	0112H	0113H	0119H		0122H	0117H	0107H
011H	294	157	158	159		132	151	152
	1	1	1	1		1	1	1
	JCC		JCR	JCR	JCR			JCC
	0130H		0123H	0124H	0127H			0167H
012H	295		133	134	135			136
	1		1	2	1			1
	JCC				JFL	JCR	JCR	JCR
	0140H				0142H	0134H	0135H	0136H
013H	296				361	360	359	358
	1				1	1	1	1
	JCC		JCR	JCR	JCC	JCR	JCC	JCC
	0150H		0147H	0146H	0104H	0144H	0196H	0157H
014H	297		365	362	326	325	363	366
	1		1	1	1	1	1	1
	JCR				JFL		JCC	JCC
	0158H				0162H		0116H	0187H
015H	298				322		150	367
	1				1		1	1
	JCR	JFL	JCR	JCR		JCC	JCR	JCC
	0162H	0172H	0166H	0165H		0145H	016CH	01A7H
016H	301	352	302	323		324	303	137
	1	1	2	1		1	1	1
	JCC	JCC	JCR	JCR	JCR	JCR		JCC
	0180H	0161H	0177H	0175H	0172H	0177H		0137H
017H	314	351	356	353	355	354		357
	1	1	2	1	1	1		2

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MICROPROGRAM MEMORY IMAGE

Addr	0H	1H	2H	3H	4H	5H	6H	7H
	JCC	JCC	JCC	JCR	JFL	JCR	JCC	JCR
	0190H	0171H	0192H	0185H	0182H	0182H	0156H	0184H
018H	315	350	375	370	369	371	149	368
	1	1	2	1	1	1	1	1
	JFL	JCC	JCR	JCR	JCC	JCC	JCR	JCR
	0192H	01A1H	0191H	0195H	0154H	01A5H	0192H	0190H
019H	316	318	317	331	321	332	364	312
	2	1	3	1	1	1	1	1
	JCC	JCR			JCC	JCR		JCC
	01B0H	01A4H			0194H	01A0H		01B7H
01AH	334	319			320	333		138
	1	1			1	1		1
	JCC	JCC	JCR	JCR	JCC		JCC	JCC
	01C0H	0181H	01B1H	0184H	0174H		0186H	01C7H
01BH	335	349	348	346	347		148	139
	1	1	1	1	1		1	1
	JCC				JCR	JFL	JCC	JCC
	01D0H				01C5H	01B2H	01B6H	01D7H
01CH	336				344	345	147	140
	1				1	1	1	1
	JCC				JCC	JCR	JCC	JCC
	01E0H				01C4H	01D4H	01C6H	01E7H
01DH	337				343	342	146	141
	1				1	1	1	1
	JCC					JCC	JCC	JCC
	01F0H					01D5H	01D6H	01F7H
01EH	339					341	145	142
	1					1	1	1
	JCR					JCC	JCC	JCR
	01F5H					01F5H	01E6H	01F6H
01FH	339					340	144	143
	1					1	1	1

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MICROPROGRAM MEMORY IMAGE

	8H	9H	AH	BH	CH	DH	EH	FH
000H								JPR 0010H 49 17
001H	JCC 0028H 229 1	JCC 0029H 243 1	JCC 01AAH 251 1	JCC 003BH 257 1	JZR 000FH 269 1	JZR 000FH 270 1	JZR 000FH 271 1	JZR 000FH 272 1
002H	JCC 003BH 230 1	JCC 0039H 244 1			JCC 010CH 55 1			
003H	JCC 0048H 231 1	JCC 0049H 245 1		JCR 003DH 258 1		JCC 010DH 259 1		
004H	JCC 0058H 232 1	JCC 0059H 246 1						
005H	JCC 0068H 233 1	JCC 0069H 247 1						
006H	JCC 0078H 234 1	JCR 006CH 248 1			JCR 006DH 249 1	JZR 000FH 250 1		
007H	JCC 0088H 235 1	JCC 0089H 202 1						

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MICROPROGRAM MEMORY IMAGE

	8H	9H	AH	BH	CH	DH	EH	FH
	JCC	JCC			JCC	JCR		
	0098H	0099H			009CH	008CH		
008H								
	236	203			190	189		
	1	1			1	1		
	JCC	JCC			JCC	JCC		
	00A8H	00A9H			00ACH	008DH		
009H								
	237	204			191	188		
	1	1			1	1		
	JCC	JCC			JCC	JCC		
	00B8H	00B9H			00CCH	009DH		
00AH								
	238	205			192	187		
	1	1			1	1		
	JCC	JCC			JCC	JCC		
	00C8H	00C9H			00DCH	00ADH		
00BH								
	239	206			182	186		
	1	1			1	1		
	JCC	JZR			JCR	JCC	JZR	
	00D8H	000FH			00CEH	00BDH	000FH	
00CH								
	240	207			193	185	194	
	1	1			1	1	1	
	JZR				JCR	JCC		
	000FH				00DDH	00CDH		
00DH								
	241				183	184		
	1				1	1		
	JZR	JCR			JCR	JCR		
	000FH	00E8H			00E9H	00ECH		
00EH								
	228	227			226	225		
	1	1			1	1		
	JCR	JCR			JCR	JCC		
	00F9H	00FCH			00FDH	00FDH		
00FH								
	221	222			223	224		
	1	1			1	1		

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MICROPROGRAM MEMORY IMAGE

```
          8H       9H       AH       BH       CH       DH       EH       FH
    ================================================================================
       =  JCC  .   JCR  *   JCR  *   JCR  *   JCC  .   JCC  .   JZR  ,        .
       = 0148H .  010BH *  010BH *  010EH *  011CH .  012DH .  000FH ,        .
    010H        .        *        *        *        .        .        ,        .
       =  164  .   163  *   168  *   169  *    56  .   260  .   170  ,        .
       =    1  .     1  *     1  *     1  *     1  .     1  .     1  .        .
       = -  -  -   -  - *- - - - -*- - - - -*- -  - -  -  - -  -  - -  -  -  .
       =  JCC  .   JCC  *   JCR  *   JCR  *   JCR  .   JCR  .   JCC  ,        .
       = 0128H .  0109H *  011DH *  0118H *  011AH .  011EH .  012EH ,        .
    011H        .        *        *        *        .        .        ,        .
       =   92  .   162  *    58  *    91  *    57  .    59  .    60  ,        .
       =    1  .     1  *     2  *     1  *     1  .     1  .     1  .        .
       = -  -  -   -  - *- - - - -*- - - - -* - - -  - -  - -  -  - -  -  -  .
       =  JCC  .   JFL  *   JCC  *   JZR  *            .   JCC  .   JCC  .        .
       = 0138H .  011AH *  010AH *  000FH *            .  013DH .  013EH ,        .
    012H        .        *        *        *            .        .        ,        .
       =   93  .    90  *   167  *   171  *            .   261  .    61  .        .
       =    1  .     1  *     1  *     1  *            .     1  .     1  .        .
       = -  -  -   -  - *- - - - -*- - - - -*  - -  - -  -  - -  -  - -  -  -  .
       =  JZR  .   JCC  *                           .   JCC  .   JCC  .        .
       = 000FH .  0129H *                           .  014DH .  014EH ,        .
    013H        .        *                           .        .        ,        .
       =   94  .    89  *                           .   262  .    62  ,        .
       =    1  .     1  *                           .     1  .     1  .        .
    ---=-------------*--------*--------*-------------------------------
       =  JCR  .   JCC  *                *  JFL  .   JCC  .   JCC  .        .
       = 014CH .  0139H *                *  012AH .  015DH .  015EH ,        .
    014H        .        *                *        .        .        ,        .
       =  165  .    88  *                *  166  .   263  .    63  .        .
       =    1  .     1  *                *    1  .     1  .     1  .        .
       = -  -  -   -  - *- - - - -*- - - - -*- - -  - -  - -  -  - -  -  -  .
       =  JCC  .   JCC  *                *            .   JCC  .   JCC  .        .
       = 0168H .  0149H *                *            .  016DH .  016EH ,        .
    015H        .        *                *            .        .        ,        .
       =  299  .    87  *                *            .   264  .    64  .        .
       =    1  .     1  *                *            .     1  .     1  .        .
       = -  -  -   -  - *- - - - -*- - - - -*  - -  - -  -  - -  -  - -  -  -  .
       =  JCR  .   JCC  *                *  JFL  .   JCC  .   JCC  .        .
       = 0160H .  0159H *                *  017AH .  017DH .  017EH ,        .
    016H        .        *                *        .        .        ,        .
       =  300  .    86  *                *  306  .   265  .    65  ,        .
       =    1  .     1  *                *    1  .     1  .     1  .        .
       = -  -  -   -  - *- - - - -*- - - - -*- - -  - -  - -  -  - -  -  -  .
       =  JCC  .   JCC  *   JCR  *   JCR  *   JCR  .   JCC  .   JCC  .        .
       = 0188H .  0169H *  0170H *  017CH *  0178H .  018DH .  018EH ,        .
    017H        .        .        *        *        .        .        ,        .
       =  309  .    85  *   313  *   307  *   308  .   266  .    66  ,        .
       =    1  .     1  *     1  *     1  *     1  .     1  .     1  .        .
    ================================================================================
```

42

MICROPROGRAM MEMORY IMAGE

Addr	8H	9H	AH	BH	CH	DH	EH	FH
	JCC					JCC	JCC	
	0198H					019DH	019EH	
018H								
	310					267	67	
	1					1	1	
	JCR					JZR	JCC	
	0197H					000FH	01AEH	
019H								
	311					268	68	
	1					1	1	
		JCR	JZR	JCR	JCR	JCC	JFL	
		01ACH	000FH	01ADH	01AFH	01BEH	01AAH	
01AH								
		252	256	253	254	69	255	
		2	1	1	1	1	1	
							JCC	
							01CEH	
01BH								
							70	
							1	
							JCC	
							01DEH	
01CH								
							71	
							1	
		JCC	JCR	JCR	JFL	JCC	JCR	
		0179H	01DDH	01D9H	01DAH	01FDH	01DAH	
01DH								
		84	73	83	82	74	72	
		1	2	1	1	1	1	
				JCC	JCR	JCR	JCR	
				01DCH	01ECH	01EDH	01EEH	
01EH								
				81	80	79	78	
				1	1	1	1	
					JCR	JCR	JCC	
					01FEH	01FFH	01EFH	
01FH								
					75	76	77	
					1	1	1	

43

CROSS REFERENCE DIRECTORY

LABEL	REFERENCES
ADDR	(58),90
BLACK	166,(171)
BLACKK	306,(307)
CADDR	(287),330
CLOAD	(302),322
CNTRD	49,(274)
DATA	316,(331)
EGATES	49,(106)
ENDC	330,(372)
FETCH	(49),94,98,104,170,171,194,207,228,241,250,256,268,269,270,271,272,
	374
FRAME	50,(251)
JGT	82,(83)
JGTL	322,(323)
LOADD	(73),82
MEAN	49,(53)
MINX	119,(120)
MINY	132,(133)
NGATEA	49,(174)
NGATEB	50,(195)
NGATEC	50,(208)
NGATEL	50,(229)
NODAT	369,371,(375)
NODATA	316,(317),364,375
NOMINX	119,(121)
NOMINY	132,(134)
NOTC	50,(269)
NOTD	50,(270)
NOTE	50,(271)
NOTF	51,(272)
NXBL	354,(357)
NXBLG	352,(356)
NXBLG2	347,(355)
NXEEG	345,(348)
NYEEG	361,(365)
OVER	312,(316)
RDY	255,(256)
RESTIJ	49,(99)
RTNN	90,(91)
SAVEIJ	49,(95)
START	50,(257)
WAT	(252),255
WHITE	166,(167
WHITEE	306,(313)
WINDOW	50,(243)
XBLG	352,(353)
XEEG	345,(346)
YBLG	369,(370)
YEEG	361,(362)

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Appendix C.

TRACKER MICRO CODE LISTING WITH EXPANDED BITS

```
RECORD              CPE      FI  FO   JUMP     KBUSS   OTHER   CBUS   PAUSE
NUMBER              6543210  10  10   6543210  43210   43210   210    0

    1
    2   KBUSS      FIELD  LENGTH=5   DEFAULT=0
    3                     MICROPS(KFFFFF=10101B   KFFFFA=10100B    K7FFFF=10011B
    4                             K80000=10010B   K00FFF=10001B    K00060=10000B
    5                             K0000F=01111B   K0000E=01110B    K0000D=01101B
    6                             K0000C=01100B   K0000A=01011B    K0000A=01010B
    7                             K00009=01001B   K00008=01000B    K00007=00111B
    8                             K00006=00110B   K00005=00101B    K00004=00100B
    9                             K00003=00011B   K00002=00010B    K00001=00001B
   10                             K00000=00000B);
   11   KBUSS      KBUS:
   12
   13   /* ALL MICROCODE IS ON PAGE2 WITH DEFAULT SET TO 00001 FOR OTHER */
   14   OTHER      FIELD  LENGTH=5   DEFAULT=00001B
   15              MICROPS(STROBE=10000B  PAGE1=00000B  PAGE2=00001B
   16                      STROBE2=10001B);
   17
   18   /* DEFINITION OF BUS CONTROL FIELD               */
   19
   20   CBUS       FIELD  LENGTH=3              DEFAULT=0
   21              MICROPS(NBO=000B   INH=001B   RMW=010B   CNB=011B
   22                      RIN=100B   ROT=101B   RRM=110B   RWM=111B);
   23
   24   /*         NBO    NOBUS OPERATION
   25              INH    INHIBIT CPE ARRAY
   26              RMW    READ-MODIFY-WRITE
   27              CNB    CPU NEEDS BUS
   28              RIN    REQUEST INPUT
   29              ROT    REQUEST OUTPUT
   30              RDM    REQUEST READ MEMORY
   31              RWM    REQUEST WRITE MEMORY
   32
   33              SET UP SYMBOLIC REPRESENTATION OF REGISTER DESIGNATIONS */
   34
   35   A          STRING 'R0':
   36   I          STRING 'R1':
   37   J          STRING 'R2':
   38   P          STRING 'R3':
   39   K          STRING 'R4':
   40   L          STRING 'R5':
   41   TEMP       STRING 'R6':
   42   TEMP2      STRING 'R7':
   43   M          STRING 'R8':
   44
   45   PAUSE      FIELD  LENGTH=1   DEFAULT=1
   46                     MICROPS(PP=0):
   47
   48
   49   OFH:       FETCH: NOP(A) JPR(CNTRD MEAN SAVEIJ RESTIJ EGATES NGATEA
   50                     NGATEB NGATEC NGATEL WINDOW FRAME START NOTC NOTD NOTE
   51                     NOTF):
        (000FH)  1100000  11  00   1100001  00000   00001   000    1
```

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RECORD NUMBER	CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0

```
   52  /*        CALCULATE MEAN VALUE FOR 100 BY 100 ARRAY   BEING DIGITIZED   */
   53  11H!      MEAN! CLA(AC)!
       (0011H)  1001011  11  00  0000010  00000  00001  000      1

   54  21H!            SDR(R6) FF1!
       (0021H)  0100110  11  11  0111100  11111  00001  000      1

   55  2CH!            SDR(M) FF1!
       (002CH)  0101000  11  11  0010000  11111  00001  000      1

   56  10CH!           ILR(J)!
       (010CH)  0000010  11  00  0010001  00000  00001  000      1

   57  11CH!           SDR(A) FF1!
       (011CH)  0100000  11  11  0111010  11111  00001  000      1

   58  11AH!     ADDR! ILR(I)!
       (011AH)  0000001  11  00  0111101  00000  00001  000      1

   59  11DH!           DCA(AC)!
       (011DH)  0011111  11  00  0111110  11111  00001  000      1

   60  11EH!           CLA(T)!
       (011EH)  1001010  11  00  0010010  00000  00001  000      1

   61  12EH!           ALR(AC)!
       (012EH)  0001101  11  00  0010011  11111  00001  000      1

   62  13EH!           ALR(AC)!
       (013EH)  0001101  11  00  0010100  11111  00001  000      1

   63  14EH!           ALR(T)!
       (014EH)  0001100  11  00  0010101  11111  00001  000      1

   64  15EH!           ALR(AC)!
       (015EH)  0001101  11  00  0010110  11111  00001  000      1

   65  16EH!           ALR(AC)!
       (016EH)  0001101  11  00  0010111  11111  00001  000      1

   66  17EH!           ALR(AC)!
```

47

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
	(017EH)	0001101	11	00	0011000	11111	00001	000	1
67	18EH!		ADR(T)!						
	(01AEH)	0111100	11	00	0011001	11111	00001	000	1
68	19EH!		ALR(AC)!						
	(019FH)	0001101	11	00	0011010	11111	00001	000	1
69	1AEH!		ALR(T)!						
	(01AEH)	0001100	11	00	0011011	11111	00001	000	1
70	1BEH!		ILR(J)!						
	(01BEH)	0000010	11	00	0011100	00000	00001	000	1
71	1CEH!		ALR(T)!						
	(01CEH)	0001100	11	00	0011101	11111	00001	000	1
72	1DEH!		SDR(T)!						
	(01DEH)	0101100	11	00	0111010	11111	00001	000	1
73	1DAH!	LOADD!	LMI(T) FF1 RRM!						
	(01DAH)	0011100	11	11	0111101	00000	00001	110	1
74	1DDH!		LDI(AC) FF1!						
	(01DDH)	0101111	11	11	0011111	11111	00001	000	1
75	1FDH!		ALR(R6)!						
	(01FDH)	0000110	11	00	0111110	11111	00001	000	1
76	1FEH!		ILR(M) FF1!						
	(01FEH)	0001000	11	11	0111111	00000	00001	000	1
77	1FFH!		ILR(L)!						
	(01FFH)	0000101	11	00	0011110	00000	00001	000	1
78	1EFH!		SDR(R7) FF1!						
	(01FFH)	0100111	11	11	0111110	11111	00001	000	1
79	1EEH!		CMR(R7)!						
	(01EEH)	1110111	11	00	0111101	00000	00001	000	1

48

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
80	1EDH!			ILR(J) FF1!					
	(01EDH)	0000010	11	11	0111100	00000	00001	000	1
81	1ECH!			ALR(R7) FF1!					
	(01ECH)	0000111	11	11	0011101	11111	00001	000	1
82	1DCH!			NOP(AC) JFL(LOADD,JGT)!					
	(01DCH)	1101101	11	00	1001101	00000	00001	000	1
83	1DBH!	JGT!		ILR(A)!					
	(01DBH)	0000000	11	00	0111001	00000	00001	000	1
84	1D9H!			SDR(J) FF1!					
	(01D9H)	0100010	11	11	0010111	11111	00001	000	1
85	179H!			ILR(K)!					
	(0179H)	0000100	11	00	0010110	00000	00001	000	1
86	169H!			SDR(R7) FF1!					
	(0169H)	0100111	11	11	0010101	11111	00001	000	1
87	159H!			CMR(R7)!					
	(0159H)	1110111	11	00	0010100	00000	00001	000	1
88	149H!			ILR(I) FF1!					
	(0149H)	0000001	11	11	0010011	00000	00001	000	1
89	139H!			ALR(R7) FF1!					
	(0139H)	0000111	11	11	0010010	11111	00001	000	1
90	129H!			NOP(AC) JFL(ADDR,RTNN)!					
	(0129H)	1101101	11	00	1000001	00000	00001	000	1
91	11BH!	RTNN!		LMI(R9) FF1!					
	(011BH)	00 1001	11	11	0111000	00000	00001	000	1
92	119H!			ILR(M) RWM!					
	(0119H)	0001000	11	00	0010010	00000	00001	111	1
93	128H!			ILR(R6)!					
	(0128H)	0000110	11	00	0010011	00000	00001	000	1

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
94	138H! (0138H)	SDR(A) FF1 JZR(FETCH) PAGE1: 0100000	11	11	0101111	11111	00000	000	1
95	12H! (0012H)	SAVEIJ! LMI(R9) FF1: 0011001	11	11	0000011	00000	00001	000	1
96	32H! (0032H)	ILR(I) RWM: 0000001	11	00	0110001	00000	00001	111	1
97	31H! (0031H)	LMI(R9): 0011001	11	00	0000100	00000	00001	000	1
98	41H! (0041H)	ILR(J) RWM JZR(FETCH) PAGE1: 0000010	11	00	0101111	00000	00000	111	1
99	13H! (0013H)	RESTIJ! LMI(R9) FF1 RRM: 0011001	11	11	0000101	00000	00001	110	1
100	53H! (0053H)	ACM(AC): 0001011	11	00	0110001	00000	00001	000	1
101	51H! (0051H)	SDR(I) FF1: 0100001	11	11	0000110	11111	00001	000	1
102	61H! (0061H)	LMI(R9) RRM: 0011001	11	00	0000111	00000	00001	110	1
103	71H! (0071H)	ACM(AC): 0001011	11	00	0001000	00000	00001	000	1
104	81H! (0081H)	SDR(J) FF1 JZR(FETCH) PAGE1: 0100010	11	11	0101111	11111	00000	000	1
105	/*	CALCULATE BOUNDARY AREA OF EDGE GATES					*/		
106	14H! (0014H)	EGATES! LMI(P) FF1 RRM: 0010011	11	11	0000010	00000	00001	110	1
107	24H! (0024H)	ACM(AC): 0001011	11	00	0000011	00000	00001	000	1
108	34H!	SDR(R6) FF1:							

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
	(0034H)	0100110	11	11	0000100	11111	00001	000	1
109	44H!			LMI(R9) FF1:					
	(0044H)	0011001	11	11	0000101	00000	00001	000	1
110	54H!			ILR(I)!					
	(0054H)	0000001	11	00	0000110	00000	00001	000	1
111	64H!			CIA(AC) FF1:					
	(0064H)	0011111	11	11	0000111	00000	00001	000	1
112	74H!			SDR(R7) FF1:					
	(0074H)	0100111	11	11	0001000	11111	00001	000	1
113	84H!			ILR(K)!					
	(0084H)	0000100	11	00	0110101	00000	00001	000	1
114	85H!			ALR(R7) RWM!					
	(0085H)	0000111	11	00	0110110	11111	00001	111	1
115	86H!			LMI(R6) FF1:					
	(0086H)	0010110	11	11	0110111	00000	00001	000	1
116	87H!			SRA(AC)!					
	(0087H)	0001111	11	00	0001001	00000	00001	000	1
117	97H!			SRA(AC)!					
	(0097H)	0001111	11	00	0110110	00000	00001	000	1
118	96H!			TZA(AC)!					
	(0096H)	1011111	11	00	0110101	11111	00001	000	1
119	95H!			NOP(AC) JFL(MINX,NOMINX)!					
	(0095H)	1101101	11	00	1001010	00000	00001	000	1
120	0A2H!	MINX!	INA(AC) FF1!						
	(00A2H)	0111111	11	11	0110011	00000	00001	000	1
121	0A3H!	NOMINX!	SDR(A) FF1 RWM!						
	(00A3H)	0100000	11	11	0110100	11111	00001	111	1

51

RECORD NUMBER		CPF 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
122	0A4H!		LMI(R9) FF1:						
	(00A4H)	0011001	11	11	0110101	00000	00001	000	1
123	0A5H!		ILR(J):						
	(00A5H)	0000010	11	00	0110110	00000	00001	000	1
124	0A6H!		CIA(AC) FF1:						
	(00A6H)	0011111	11	11	0001011	00000	00001	000	1
125	0B6H!		SDR(R7) FF1:						
	(00B6H)	0100111	11	11	0001100	11111	00001	000	1
126	0C6H!		ILR(L):						
	(00C6H)	0000101	11	00	0001101	00000	00001	000	1
127	0D6H!		ALR(R7) RWM:						
	(00D6H)	0000111	11	00	0001110	11111	00001	111	1
128	0E6H!		LMI(R6) FF1:						
	(00E6H)	0010110	11	11	0001111	00000	00001	000	1
129	0F6H!		SRA(AC):						
	(00F6H)	0001111	11	00	0010000	00000	00001	000	1
130	106H!		SRA(AC):						
	(0106H)	0001111	11	00	0110101	00000	00001	000	1
131	105H!		TZA(AC):						
	(0105H)	1011111	11	00	0010001	11111	00001	000	1
132	115H!		NOP(AC) JFL(MINY,NOMINY):						
	(0115H)	1101101	11	00	1000010	00000	00001	000	1
133	122H!	MINY! INA(AC) FF1:							
	(0122H)	0111111	11	11	0110011	00000	00001	000	1
134	123H!	NOMINY! SDR(R7) FF1 RWM:							
	(0123H)	0100111	11	11	0110100	11111	00001	111	1
135	124H!		ILR(R9) FF1:						
	(0124H)	0001001	11	11	0110111	00000	00001	000	1

52

RECORD NUMBER		CPF 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
136	127H! (0127H)	ILR(R9) FF1; 0001001	11	11	0010110	00000	00001	000	1
137	167H! (0167H)	ILR(A); 0000000	11	00	0011010	00000	00001	000	1
138	1A7H! (01A7H)	CIA(AC) FF1; 0011111	11	11	0011011	00000	00001	000	1
139	187H! (0197H)	SDR(R8) FF1; 0101000	11	11	0011100	11111	00001	000	1
140	1C7H! (01C7H)	ILR(I); 0000001	11	00	0011101	00000	00001	000	1
141	1D7H! (01D7H)	ALR(A); 0000000	11	00	0011110	11111	00001	000	1
142	1E7H! (01E7H)	LMI(R9) FF1 RWM; 0011001	11	11	0011111	00000	00001	111	1
143	1F7H! (01F7H)	ILR(R9) FF1; 0001001	11	11	0110110	00000	00001	000	1
144	1F6H! (01F6H)	LMI(R9) FF1; 0011001	11	11	0011110	00000	00001	000	1
145	1E6H! (01E6H)	ILR(K); 0000100	11	00	0011101	00000	00001	000	1
146	1D6H! (01D6H)	ALR(R8); 0001000	11	00	0011100	11111	00001	000	1
147	1C6H! (01C6H)	CIA(AC) FF1 RWM; 0011111	11	11	0011011	00000	00001	111	1
148	1B6H! (01B6H)	ILR(R7); 0000111	11	00	0011000	00000	00001	000	1
149	1B6H! (01B6H)	CIA(AC) FF1; 0011111	11	11	0010101	00000	00001	000	1

53

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
150	156H!		SDR(R8) FF1:						
	(0156H)	0101000	11	11	0010001	11111	00001	000	1
151	116H!		ILR(R9) FF1:						
	(0116H)	0001001	11	11	0110111	00000	00001	000	1
152	117H!		ILR(J):						
	(0117H)	0000010	11	00	0010000	00000	00001	000	1
153	107H!		ALR(R7):						
	(0107H)	0000111	11	00	0110011	11111	00001	000	1
154	103H!		LMI(R9) FF1 RWM:						
	(0103H)	0011001	11	11	0110010	00000	00001	111	1
155	102H!		ILR(R9) FF1:						
	(0102H)	0001001	11	11	0110001	00000	00001	000	1
156	101H!		ILR(L):						
	(0101H)	0000101	11	00	0010001	00000	00001	000	1
157	111H!		ALR(R8):						
	(0111H)	0001000	11	00	0110010	11111	00001	000	1
158	112H!		CIA(AC) FF1:						
	(0112H)	0011111	11	11	0110011	00000	00001	000	1
159	113H!		LMI(R9) FF1 RWM:						
	(0113H)	0011001	11	11	0111001	00000	00001	111	1
160	/*	IF MEAN VLAUE IS LESS THAN SEVEN TRACK BLACK ON WHITE							
161		IF MEAN VALUE IS GREATER OR EQUAL TO SEVEN TRACK WHITE ON BLACK*/							
162	119H!		CLR(R9):						
	(0119H)	1001001	11	00	0010000	00000	00001	000	1
163	109H!		LMI(R9) K0000F FF1:						
	(0109H)	0011001	11	11	0111000	01111	00001	000	1
164	108H!		LMI(R9) RRM:						
	(0108H)	0011001	11	00	0010100	00000	00001	110	1

54

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
165	148H!				ACM(AC) FF1 STZ;				
	(0148H)	0001011	01	11	0111100	00000	00001	000	1
166	14CH!				NOP(AC) JFL(WHITE,BLACK);				
	(014CH)	1101101	11	00	1000010	00000	00001	000	1
167	12AH!	WHITE! CLR(R9);							
	(012AH)	1001001	11	00	0010000	00000	00001	000	1
168	10AH!				LMI(R9) K00005 RRM;				
	(010AH)	0011001	11	00	0111011	00101	00001	110	1
169	10BH!				LCM(AC);				
	(010BH)	1111011	11	00	0111110	00000	00001	000	1
170	10EH!				INA(AC) FF1 RWM PAGE1 JZR(FETCH);				
	(010EH)	0111111	11	11	0101111	00000	00000	111	1
171	12BH!	BLACK! NOP(AC) PAGE1 JZR(FETCH);							
	(012BH)	1101101	11	00	0101111	00000	00000	000	1
172	/*	NGATEA NGATEB NGATEC AND NGATEL CALCULATE EDGES OF THE GATE							
173		AND THE NEW I J K L */							
174	15H!	NGATEA! LMI(R9) RRM;							
	(0015H)	0011001	11	00	0000010	00000	00001	110	1
175	25H!				ACM(AC);				
	(0025H)	0001011	11	00	0000011	00000	00001	000	1
176	35H!				CIA(AC) FF1;				
	(0035H)	0011111	11	11	0000100	00000	00001	000	1
177	45H!				SDR(R6) FF1;				
	(0045H)	0100110	11	11	0000101	11111	00001	000	1
178	55H!				CLR(R7);				
	(0055H)	1000111	11	00	0000110	00000	00001	000	1
179	65H!				LMI(R7) K00007;				
	(0065H)	0010111	11	00	0000111	00111	00001	000	1

55

RECORD NUMBER		CPF 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
180	75H! (0075H)	0010111	11	11	LMI(R7) FF1 RRM: 0001011	00000	00001	110	1
181	0B5H! (00B5H)	0001011	11	00	ACM(AC): 0111100	00000	00001	000	1
182	0BCH! (00BCH)	0010111	11	11	LMI(R7) FF1: 0001101	00000	00001	000	1
183	0DCH! (00DCH)	0010111	11	00	LMI(R7) RRM: 0111101	00000	00001	110	1
184	0DDH! (00DDH)	0001011	11	00	AMA(AC): 0001100	11111	00001	000	1
185	0CDH! (00CDH)	0110110	11	00	ADR(R6): 0001011	11111	00001	000	1
186	0BDH! (00BDH)	1000111	11	00	CLR(R7): 0001010	00000	00001	000	1
187	0ADH! (00ADH)	0010111	11	00	LMI(R7) K00003: 0001001	00011	00001	000	1
188	9DH! (009DH)	0010111	11	00	LMI(R7) RRM: 0001000	00000	00001	110	1
189	8DH! (008DH)	0001011	11	00	ACM(AC): 0111100	00000	00001	000	1
190	8CH! (008CH)	0001101	11	00	ALR(AC): 0001001	11111	00001	000	1
191	9CH! (009CH)	0001101	11	00	ALR(AC): 0001010	11111	00001	000	1
192	0ACH! (00ACH)	0011001	11	11	LMI(R9) FF1 RWM: 0001100	00000	00001	111	1
193	0CCH! (00CCH)	0000110	11	00	ALR(R6): 0111110	11111	00001	000	1

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RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
194	0CEH! (00CEH)	SDR(A) FF1 JZR(FETCH) PAGE1: 0100000	11	11	0101111	11111	00000	000	1
195	16H! (0016H)	NGATEB! LMI(R9) RRM: 0011001	11	00	0000010	00000	00001	110	1
196	26H! (0026H)	ACM(AC): 0001011	11	00	0000011	00000	00001	000	1
197	36H! (0036H)	SRA(AC): 0001111	11	00	0000100	00000	00001	000	1
198	46H! (0046H)	ALR(A): 0000000	11	00	0000101	11111	00001	000	1
199	56H! (0056H)	SDR(A) FF1: 0100000	11	11	0000110	11111	00001	000	1
200	66H! (0066H)	CIA(AC) FF1: 0011111	11	11	0000111	00000	00001	000	1
201	76H! (0076H)	LMI(P) FF1 RRM: 0010011	11	11	0111001	00000	00001	110	1
202	79H! (0079H)	LMM(T) RRM: 0011010	11	00	0001000	00000	00001	110	1
203	89H! (0089H)	AMA(AC): 0001011	11	00	0001001	11111	00001	000	1
204	99H! (0099H)	SDR(I) FF1: 0100001	11	11	0001010	11111	00001	000	1
205	0A9H! (00A9H)	ILR(A) RRM: 0000000	11	00	0001011	00000	00001	110	1
206	0B9H! (00B9H)	AMA(AC): 0001011	11	00	0001100	11111	00001	000	1
207	0C9H! (00C9H)	SDR(K) FF1 JZR(FETCH) PAGE1: 0100100	11	11	0101111	11111	00000	000	1

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RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
208	17H! (0017H)	NGATEC! LMI(R9) RRM! 0011001	11	00	0000010	00000	00001	110	1
209	27H! (0027H)	ACM(AC)! 0001011	11	00	0000011	00000	00001	000	1
210	37H! (0037H)	CIA(AC) FF1: 0011111	11	11	0000100	00000	00001	000	1
211	47H! (0047H)	SDR(R6) FF1: 0100110	11	11	0000101	11111	00001	000	1
212	57H! (0057H)	CLR(R7)! 1000111	11	00	0000110	00000	00001	000	1
213	67H! (0067H)	LMI(R7) K00009! 0010111	11	00	0000111	01011	00001	000	1
214	77H! (0077H)	LMI(R7) FF1 RRM! 0010111	11	11	0001010	00000	00001	110	1
215	0A7H! (00A7H)	ACM(AC)! 0001011	11	00	0001011	00000	00001	000	1
216	0B7H! (00B7H)	LMI(R7) FF1: 0010111	11	11	0001100	00000	00001	000	1
217	0C7H! (00C7H)	LMI(R7) RRM! 0010111	11	00	0001101	00000	00001	110	1
218	0D7H! (00D7H)	AMA(AC)! 0001011	11	00	0001110	11111	00001	000	1
219	0E7H! (00F7H)	ADR(R6)! 0110110	11	00	0001111	11111	00001	000	1
220	0F7H! (00F7H)	CLR(R7)! 1000111	11	00	0111000	00000	00001	000	1
221	0F8H! (00F8H)	LMI(R7) K00002! 0010111	11	00	0111001	00010	00001	000	1

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
222	0F9H! (00F9H)	0010111	LMI(R7) 11	RRM! 00	0111100	00000	00001	110	1
223	0FCH! (00FCH)	0001011	ACM(AC); 11	00	0111101	00000	00001	000	1
224	0FDH! (00FDH)	0001101	ALR(AC); 11	00	0001110	11111	00001	000	1
225	0EDH! (00EDH)	0001101	ALR(AC); 11	00	0111100	11111	00001	000	1
226	0ECH! (00FCH)	0011001	LMI(R9) 11	FF1 RWM! 11	0111001	00000	00001	111	1
227	0E9H! (00E9H)	0000110	ALR(R6); 11	00	0111000	11111	00001	000	1
228	0E8H! (00E8H)	0100000	SDR(A) FF1 JZR(FETCH) PAGE1! 11	11	0101111	11111	00000	000	1
229	18H! (0018H)	NGATFL! LMI(R9) RRM! 0011001	11	00	0000010	00000	00001	110	1
230	28H! (0028H)	0001011	ACM(AC); 11	00	0000011	00000	00001	000	1
231	38H! (0038H)	0001111	SRA(AC); 11	00	0000100	00000	00001	000	1
232	48H! (0048H)	0000000	ALR(A); 11	00	0000101	11111	00001	000	1
233	58H! (0058H)	0100000	SDR(A) FF1! 11	11	0000110	11111	00001	000	1
234	68H! (0068H)	0011111	CIA(AC) FF1; 11	11	0000111	00000	00001	000	1
235	78H! (0078H)	0010011	LMI(P) FF1 RRM! 11	11	0001000	00000	00001	110	1

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RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KRUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
236	88H!		LMM(T) RRM:						
	(0088H)	0011010	11	00	0001001	00000	00001	110	1
237	98H!		AMA(AC):						
	(0098H)	0001011	11	00	0001010	11111	00001	000	1
238	0A8H!		SDR(J) FF1:						
	(00A8H)	0100010	11	11	0001011	11111	00001	000	1
239	0B8H!		ILR(A) RRM:						
	(00B8H)	0000000	11	00	0001100	00000	00001	110	1
240	0C8H!		AMA(AC):						
	(00C8H)	0001011	11	00	0001101	11111	00001	000	1
241	0D8H!		SDR(L) FF1 JZR(FETCH) PAGE1:						
	(00D8H)	0100101	11	11	0101111	11111	00000	000	1
242	/*	WINDOW-----(VARIABLE WINDOW MICROROUTINE)						*/	
243	19H!	WINDOW! LMI(R9) FF1:							
	(0019H)	0011001	11	11	0000010	00000	00001	000	1
244	29H!		ILR(J) ROT:						
	(0029H)	0000010	11	00	0000011	00000	00001	101	1
245	39H!		LMI(R9) FF1:						
	(0039H)	0011001	11	11	0000100	00000	00001	000	1
246	49H!		ILR(L) ROT:						
	(0049H)	0000101	11	00	0000101	00000	00001	101	1
247	59H!		LMI(R9) FF1:						
	(0059H)	0011001	11	11	0000110	00000	00001	000	1
248	69H!		ILR(I) ROT:						
	(0069H)	0000001	11	00	0111100	00000	00001	101	1
249	6CH!		LMI(R9) FF1:						
	(006CH)	0011001	11	11	0111101	00000	00001	000	1
250	6DH!		ILR(K) ROT JZR(FETCH) PAGE1:						

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KRUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
	(006DH)	0000100	11	00	0101111	00000	00000	101	1
251	1AH! FRAME! NOP(R8) STROBE2:								
	(001AH)	11 1000	11	00	0011010	00000	10001	000	1
252	1AAH! WAT! NOP(R8) RIN:								
	(01AAH)	1101000	11	00	0111100	00000	00001	100	1
253	1ACH! LDI(AC) FF1:								
	(01ACH)	0101111	11	11	0111101	11111	00001	000	1
254	1ADH! TZR(AC) K80000:								
	(01ADH)	1011101	11	00	0111111	10010	00001	000	1
255	1AFH! NOP(R8) JFL(WAT,RDY):								
	(01AFH)	1101000	11	00	1001010	00000	00001	000	1
256	1ABH! RDY! NOP(R8) JZR(FETCH) PAGE1:								
	(01ABH)	1101000	11	00	0101111	00000	00000	000	1
257	18H! START! LMI(R9) FF1 RRM:								
	(0018H)	00?1001	11	11	0000011	00000	00001	110	1
258	3BH! ACM(AC):								
	(003BH)	0001011	11	00	0111101	00000	00001	000	1
259	3DH! SDR(I) FF1:								
	(003DH)	0100001	11	11	0010000	11111	00001	000	1
260	10DH! LMI(R9) FF1 RRM:								
	(010DH)	0011001	11	11	0010010	00000	00001	110	1
261	12DH! ACM(AC):								
	(012DH)	0001011	11	00	0010011	00000	00001	000	1
262	13DH! SDR(J) FF1:								
	(013DH)	0100010	11	11	0010100	11111	00001	000	1
263	14DH! LMI(R9) FF1 RRM:								
	(014DH)	0011001	11	11	0010101	00000	00001	110	1

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RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KRUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
264	15DH!		ACM(AC):						
	(015DH)	0001011	11	00	0010110	00000	00001	000	1
265	16DH!		SDR(K) FF1:						
	(016DH)	0100100	11	11	0010111	11111	00001	000	1
266	17DH!		LMI(R9) RRM:						
	(017DH)	0011001	11	00	0011000	00000	00001	110	1
267	18DH!		ACM(AC):						
	(018DH)	0001011	11	00	0011001	00000	00001	000	1
268	19DH!		SDR(L) FF1 JZR(FETCH) PAGE1:						
	(019DH)	0100101	11	11	0101111	11111	00000	000	1
269	1CH!	NOTC!	NOP(A) JZR(FETCH) PAGE1:						
	(001CH)	1100000	11	00	0101111	00000	00000	000	1
270	1DH!	NOTD!	NOP(A) JZR(FETCH) PAGE1:						
	(001DH)	1100000	11	00	0101111	00000	00000	000	1
271	1EH!	NOTE!	NOP(A) JZR(FETCH) PAGE1:						
	(001EH)	1100000	11	00	0101111	00000	00000	000	1
272	1FH!	NOTF!	NOP(A) JZR(FETCH) PAGE1:						
	(001FH)	1100000	11	00	0101111	00000	00000	000	1
273	/*	CENTROID CALCULATIONS AND TARGET AREAS OF EDGE GATES						*/	
274	10H!	CNTRD! CLA(AC):							
	(0010H)	1001011	11	00	0000000	00000	00001	000	1
275	00H!	SDR(M) FF1:							
	(0000H)	0101000	11	11	0000010	11111	00001	000	1
276	20H!	. LMI(R9) FF1 RWM:							
	(0020H)	0011001	11	11	0000011	00000	00001	111	1
277	30H!	LMI(R9) FF1:							
	(0030H)	0011001	11	11	0000100	00000	00001	000	1
278	40H!	LMI(R9) FF1 RWM:							

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RECORD NUMBER		CPF 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
	(0040H)	0011001	11	11	0000101	00000	00001	111	1
279	50H!				LMI(R9) FF1!				
	(0050H)	0011001	11	11	0000110	00000	00001	000	1
280	60H!				LMI(R9) FF1 RWM!				
	(0060H)	0011001	11	11	0000111	00000	00001	111	1
281	70H!				LMI(R9) FF1!				
	(0070H)	0011001	11	11	0001000	00000	00001	000	1
282	80H!				LMI(R9) FF1 RWM!				
	(0080H)	0011001	11	11	0001001	00000	00001	111	1
283	90H!				LMI(R9) FF1 RWM!				
	(0090H)	0011001	11	11	0001010	00000	00001	111	1
284	0A0H!				LMI(R9) RWM!				
	(00A0H)	0011001	11	00	0001011	00000	00001	111	1
285	0B0H!				ILR(J)!				
	(00B0H)	0000010	11	00	0001100	00000	00001	000	1
286	0C0H!				SDR(A) FF1!				
	(00C0H)	0100000	11	11	0110010	11111	00001	000	1
287	0C2H!	CADDR!			ILR(I)!				
	(00C2H)	0000001	11	00	0110100	00000	00001	000	1
288	0C4H!				DCA(AC)!				
	(00C4H)	0011111	11	00	0001101	11111	00001	000	1
289	0D4H!	.			CLA(T)!				
	(00D4H)	1001010	11	00	0110000	00000	00001	000	1
290	0D0H!				ALR(AC)!				
	(00D0H)	0001101	11	00	0001110	11111	00001	000	1
291	0E0H!				ALR(AC)!				
	(00E0H)	0001101	11	00	0001111	11111	00001	000	1

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RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
292	0F0H! (00F0H)	A_LR(T)! 0001100	11	00	0010000	11111	00001	000	1
293	100H! (0100H)	A_LR(AC)! 0001101	11	00	0010001	11111	00001	000	1
294	110H! (0110H)	ALR(AC)! 0001101	11	00	0010010	11111	00001	000	1
295	120H! (0120H)	ALR(AC)! 0001101	11	00	0010011	11111	00001	000	1
296	130H! (0130H)	ADR(T)! 0111100	11	00	0010100	11111	00001	000	1
297	140H! (0140H)	ALR(AC)! 0001101	11	00	0010101	11111	00001	000	1
298	150H! (0150H)	ALR(T)! 0001100	11	00	0111000	11111	00001	000	1
299	158H! (0158H)	ILR(J)! 0000010	11	00	0010110	00000	00001	000	1
300	168H! (0168H)	ALR(T)! 0001100	11	00	0110000	11111	00001	000	1
301	160H! (0160H)	SDR(T)! 0101100	11	00	0110010	11111	00001	000	1
302	162H! (0162H)	CLOAD! CLR(R9)! 1001001	11	00	0110110	00000	00001	000	1
303	166H! (0166H)	TZR(R9) FFZ! 1011001	11	10	0111100	11111	00001	000	1

```
304  /*    BRANCH TO WHITEE FOR WHITE ON BLACK TARGET
305        BRANCH TO BLACKK TO TRACK ON BLACK TARGET        */
306  16CH!          LMI(R9) K00005 FF1 RRM JFL(WHITEE,BLACKK)!
     (016CH)  0011001  11  11  1000111  00101  00001  110       1
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RECORD NUMBER		CPF 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
307	17BH! (017BH)	BLACKK! ACM(AC); 0001011	11	00	0111100	00000	00001	000	1
308	17CH! (017CH)	SDR(R6) FF1; 0100110	11	11	0111000	11111	00001	000	1
309	178H! (0178H)	LMI(T) FF1 RRM; 0011100	11	11	0011000	00000	00001	110	1
310	188H! (0188H)	LDI(AC) FF1; 0101111	11	11	0011001	11111	00001	000	1
311	199H! (0199H)	CIA(AC) FF1; 0011111	11	11	0110111	00000	00001	000	1
312	197H! (0197H)	ALR(R6) JCR(OVER); 0000110	11	00	0110000	11111	00001	000	1
313	17AH! (017AH)	WHITEE! ACM(AC); 00?1011	11	00	0110000	00000	00001	000	1
314	170H! (0170H)	LMI(T) FF1 RRM; 0011100	11	11	0011000	00000	00001	110	1
315	180H! (0180H)	AIA(AC); 0111111	11	00	0011001	11111	00001	000	1
316	190H! (0190H)	OVER! NOP(AC) JFL(NODATA,DATA); 1101101	11	00	1001001	00000	00001	000	1
317	192H! (0192H)	NODATA! ILR(L); 0000101	11	00	0110001	00000	00001	000	1
318	191H! (0191H)	SDR(R6) FF1; 0100110	11	11	0011010	11111	00001	000	1
319	1A1H! (01A1H)	CMR(R6); 1110110	11	00	0110100	00000	00001	000	1
320	1A4H! (01A4H)	ILR(J) FF1; 0000010	11	11	0011001	00000	00001	000	1

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
321	194H!		ALR(R6)	FF1!					
	(0194H)	0000110	11	11	0010101	11111	00001	000	1
322	154H!		NOP(AC)	JFL(CLOAD,JGTL)!					
	(0154H)	1101101	11	00	1000110	00000	00001	000	1
323	163H!	JGTL!	ILR(A)!						
	(0163H)	0000000	11	00	0110101	00000	00001	000	1
324	165H!		SDR(J)	FF1!					
	(0165H)	0100010	11	11	0010100	11111	00001	000	1
325	145H!		ILR(K)!						
	(0145H)	0000100	11	00	0110100	00000	00001	000	1
326	144H!		SDR(R6)	FF1!					
	(0144H)	0100110	11	11	0010000	11111	00001	000	1
327	104H!		CMR(R6)!						
	(0104H)	1110110	11	00	0001111	00000	00001	000	1
328	0F4H!		ILR(I)	FF1!					
	(00F4H)	0000001	11	11	0001110	00000	00001	000	1
329	0E4H!		ALR(R6)	FF1!					
	(00F4H)	0000110	11	11	0001011	11111	00001	000	1
330	0B4H!		NOP(AC)	JFL(CADDR,ENDC)!					
	(00B4H)	1101101	11	00	1001100	00000	00001	000	1
331	193H!	DATA!	ILR(R9)!						
	(0193H)	0001001	11	00	0110101	00000	00001	000	1
332	195H!		SDR(R6)FF1!						
	(0195H)	0100110	11	11	0011010	11111	00001	000	1
333	1A5H!		LMI(R6)	K000008!					
	(01A5H)	0010110	11	00	0110000	01000	00001	000	1
334	1A0H!	ILR(I)!							
	(01A0H)	0000001	11	00	0011011	00000	00001	000	1

RECORD NUMBER		CPF 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
335	1B0H! (01B0H)	0010110	LMI(R6) 11	FF1 11	RRM: 0011100	00000	00001	110	1
336	1C0H! (01C0H)	0001011	AMA(AC) 11	RWM: 00	0011101	11111	00001	111	1
337	1D0H! (01D0H)	0000010	ILR(J): 11	00	0011110	00000	00001	000	1
338	1E0H! (01E0H)	0010110	LMI(R6) 11	RRM: 00	0011111	00000	00001	110	1
339	1F0H! (01F0H)	0001011	AMA(AC) 11	RWM: 00	0110101	11111	00001	111	1
340	1F5H! (01F5H)	0001000	ILR(M) 11	FF1: 11	0011110	00000	00001	000	1
341	1E5H! (01E5H)	0000001	ILR(I): 11	00	0011101	00000	00001	000	1
342	1D5H! (01D5H)	0011111	CIA(AC): 11	00	0110100	00000	00001	000	1
343	1D4H! (01D4H)	0011001	LMI(R9) 11	FF1 11	RRM: 0011100	00000	00001	110	1
344	1C4H! (01C4H)	0001011	AMA(AC): 11	00	0110101	11111	00001	000	1
345	1C5H! (01C5H)	1101101	NOP(AC) 11	JFL(NXEEG+XEEG): 00	1001011	00000	00001	000	1
346	1B3H! (01B3H)	0011001	XEEG! LMI(R9) 11	FF1 11	RRM: 0110100	00000	00001	110	1
347	1B4H! (01B4H)	0001011	ACM(AC) 11	FF1 11	RWM JCC(NXBLG2): 0010111	00000	00001	111	1
348	1B2H! (01B2H)	0001001	NXEEG! ILR(R9) 11	FF1: 11	0110001	00000	00001	000	1

RECORD NUMBER		CPE 6543210	FI 10	FO 10	JUMP 6543210	KBUSS 43210	OTHER 43210	CBUS 210	PAUSE 0
349	1B1H!		ILR(I)#						
	(01B1H)	0000001	11	00	0011000	00000	00001	000	1
350	181H!		LMI(R9) FF1 RRM#						
	(0181H)	0011001	11	11	0010111	00000	00001	110	1
351	171H!		AMA(AC)#						
	(0171H)	0001011	11	00	0010110	11111	00001	000	1
352	161H!		NOP(AC) JFL(NXBLG,XBLG)#						
	(0161H)	1101101	11	00	1000111	00000	00001	000	1
353	173H!	XBLG!	LMI(R9) FF1 RRM#						
	(0173H)	0011001	11	11	0110101	00000	00001	110	1
354	175H!		ACM(AC) FF1 RWM JCR(NXBL)#						
	(0175H)	0001011	11	11	0110111	00000	00001	111	1
355	174H!	NXBLG2!	ILR(R9) FF1#						
	(0174H)	0001001	11	11	0110010	00000	00001	000	1
356	172H!	NXBLG!	ILR(R9) FF1#						
	(0172H)	00 1001	11	11	0110111	00000	00001	000	1
357	177H!	NXBL!	ILR(J)#						
	(0177H)	0000010	11	00	0010011	00000	00001	000	1
358	137H!		CIA(AC)#						
	(0137H)	0011111	11	00	0110110	00000	00001	000	1
359	136H!		LMI(R9) FF1 RRM#						
	(0136H)	0011001	11	11	0110101	00000	00001	110	1
360	135H!		AMA(AC)#						
	(0135H)	0001011	11	00	0110100	11111	00001	000	1
361	134H!		NOP(AC) JFL(NYEEG,YEEG)#						
	(0134H)	1101101	11	00	1000100	00000	00001	000	1
362	143H!	YFEG!	LMI(R9) FF1 RRM#						
	(0143H)	0011001	11	11	0110110	00000	00001	110	1

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RECORD		CPE	FI	FO	JUMP	KBUSS	OTHER	CBUS	PAUSE
NUMBER		6543210	10	10	6543210	43210	43210	210	0
363 146H!				ACM(AC) FF1 RWM!					
(0146H)		0001011	11	11	0011001	00000	00001	111	1
364 196H!				NOP(A) JCR(NODATA)!					
(0196H)		1100000	11	00	0110010	00000	00001	000	1
365 142H!	NYEEG! ILR(R9) FF1!								
(0142H)		00 1001	11	11	0110111	00000	00001	000	1
366 147H!		ILR(J)!							
(0147H)		0000010	11	00	0010101	00000	00001	000	1
367 157H!				LMI(R9) FF1 RRM!					
(0157H)		0011001	11	11	0011000	00000	00001	110	1
368 187H!				AMA(AC)!					
(0187H)		0001011	11	00	0110100	11111	00001	000	1
369 184H!				NOP(AC) JFL(NODAT,YBLG)!					
(0184H)		1101101	11	00	1001000	00000	00001	000	1
370 183H!	YBLG! LMI(R9) FF1 RRM!								
(0183H)		0011001	11	11	0110101	00000	00001	110	1
371 185H!				ACM(AC) FF1 RWM JCR(NODAT)!					
(0185H)		0001011	11	11	0110010	00000	00001	111	1
372 0C3H!	ENDC! CLR(R9)!								
(00C3H)		1001001	11	00	0110101	00000	00001	000	1
373 0C5H!				LMI(R9) K00004!					
(00C5H)		0011001	11	00	0001110	00100	00001	000	1
374 0E5H!				ILR(M) RWM PAGE1 JZR(FETCH)!					
(00E5H)		0001000	11	00	0101111	00000	00000	111	1
375 182H!	NODAT! NOP(A) JCC(NODATA)!								
(0182H)		1100000	11	00	0011001	00000	00001	000	1
376 EOF									

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Appendix D.

EAI PACER 100 EMULATION MICRO CODE LISTING

```
RECORD
NUMBER

    1
    2   KBUSS       FIELD  LENGTH=5   DEFAULT=0
    3                      MICROPS(KFFFFF=10101B    KFFFFA=10102B    K7FFFF=10011B
    4                             K80000=10010B    K01FFF=10001B    K0006O=10000B
    5                             K0000F=01111B    K0000E=01110B    K0000D=01101B
    6                             K0000C=01100B    K0000B=01011B    K0000A=01010B
    7                             K00009=01001B    K00008=01000B    K00007=00111B
    8                             K00006=00110B    K00005=00101B    K00004=00100B
    9                             K00003=00011B    K00002=00010B    K00001=00001B
   10                             K00000=00000B);
   11   KBUSS       KBUS:
   12
   13   OTHER       FIELD  LENGTH=5   DEFAULT=0
   14                      MICROPS(SET1=11111B  PAGE1=00000B  PAGE2=00001B);
   15
   16   /* DEFINITION OF BUS CONTROL FIELD            */
   17
   18   CBUS        FIELD  LENGTH=3              DEFAULT=0
   19                      MICROPS(NBO=000B    INH=001B    PMW=010B    CNB=011B
   20                             RIN=100B    ROT=101B    PRM=110B    RWM=111B);
   21
   22   /*          NBO    NOBUS OPERATION
   23               INH    INHIBIT CPE ARRAY
   24               RMW    READ-MODIFY-WRITE
   25               CNB    CPU NEEDS BUS
   26               RIN    REQUEST INPUT
   27               ROT    REQUEST OUTPUT
   28               RRM    REQUEST READ MEMORY
   29               RWM    REQUEST WRITE MEMORY
   30
   31               SET UP SYMBOLIC REPRESENTATION OF REGISTER DESIGNATIONS */
   32
   33   A           STRING 'R0';
   34   X           STRING 'R1';
   35   Q           STRING 'R2';
   36   P           STRING 'R3';
   37   S           STRING 'R4';
   38   B           STRING 'R5';
   39   E           STRING 'R6';
   40   W           STRING 'R7';
   41
   42   PAUSE       FIELD  LENGTH=1   DEFAULT=1
   43                      MICROPS(SP1=1    SP0=0);
   44
   45   00H!   INIT!    CLR(A);
   46   10H!            CLR(X);
   47   20H!            CLR(W) JCC(INIT1);
   48   30H!   DIR!     LMI(AC) RRM JPR(LA STA LX STX AI SI M D AOM ORI XORI
   49                              ANDD C EE FF GG);
   50   40H!   INIT1!   CLR(T) JCC(INIT2);
   51   60H!   SE!      NOP(A) JCF(NTEQL,EQL);
   52   70H!   LA!      ACM(AC);
   53   80H!            SDR(A) FF1 JZR(FETCH);
   54   90H!   INIT2!   LMI(T);
```

RECORD
NUMBER

```
 55   0A04!              ILR(W) ROT!
 56   0B0H!              LMI(T) FF1 RRM!
 57   0C0H!              ACM(AC)!
 58   0D0H!              SDR(S) FF1!
 59   0E0H!              LMI(T) RRM!
 60   0F0H!              ACM(AC)!
 61   100H!              SDR(P) FF1 JZR(FETCH)!
 62   110H!      CLR1!   CLR(A) JZR(FETCH)!
 63   1E04!      N1!     NOP(A) JZR(FETCH)!
 64   31H!       J!      SDR(P) FF1 JZP(FETCH)!
 65   61H!       SG!     NOP(A) JCC(SGC)!
 66   71H!       STA!    ILR(A) RWM JZR(FETCH)!
 67   91H!       SGC!    NOP(A) JCF(NTEQL2,EQL2)!
 68   111H!      AOA!    ILR(A) FF1 STC JZR(FETCH)!
 69   131H!      YY!     SDR(A) FF1 JZR(FETCH)!
 70   151H!      WW!     SDR(A) FF1 JZR(FETCH)!
 71   1E1H!      N2!     NOP(A) JZR(FETCH)!
 72   02H!       N EQ3!  NOP(A) JZF(LT,NTLT)!
 73   12H!       LT!     ILR(P) FF1 JZR(FETCH)!
 74   22H!       NTEQL!  NOP(A) JZR(FETCH)!
 75   32H!       L!      LMI(S) FF1!
 76   42H!               ILR(P) RWM!
 77   52H!               ILR(R9) JCR(CL)!
 78   62H!       SL!     NOP(A) JCF(NTEQ3,EQ3)!
 79   72H!       LX!     ACM(AC)!
 80   82H!               SDR(X) FF1 JZR(FETCH)!
 81   92H!       NTEQL2!                  NOP(A) JZF(NTGT,GT)!
 82   0A2H!      NTGT!   NOP(A) JZR(FETCH)!
 83   0D2H!      NTEQL4!                       ILR(P) FF1 JZR(FETCH)!
 84   0E2H!      NTEQ5!  NOP(A) JZF(NTGT5,GT5)!
 85   0F2H!      NTGT5!  NOP(A) JZR(FETCH)!
 86   112H!      CAO!    CLR(A)!
 87   122H!              ILR(A) FF1 JZR(FETCH)!
 88   132H!      OUT2!   ALR(AC) FFZ JCR(YY)!
 89   142H!      OUT3!   NOP(A) JZR(FETCH)!
 90   162H!      NTEQ6!  NOP(A) JZF(NTGT6,GT6)!
 91   172H!      NTGT6!  ILR(P) FF1 JZR(FETCH)!
 92   1E2H!      N3!     NOP(A) JZR(FETCH)!
 93   03H!       E 3!    NOP(A) JZR(FETCH)!
 94   13H!       NTLT!   NOP(A) JZR(FETCH)!
 95   23H!       EQL!    ILR(P) FF1 JZR(FETCH)!
 96   33H!       RFG!    ILR(A) JCC(REGC)!
 97   63H!       SNE!    NOP(A) JCC(SNEC)!
 98   73H!       S X!    ILR(X) RWM JZR(FETCH)!
 99   83H!       SNEC!   NOP(A) JCF(NTEQL4,EQL4)!
100   93H!       EQL2!   NOP(A) JZR(FETCH)!
101   0A3H!      GT!     ILR(P) FF1 JZR(FETCH)!
102   0D3H!      EQL4!   NOP(A) JZR(FETCH)!
103   0E3H!      EQ5!    ILR(P) FF1 JZR(FETCH)!
104   0F3H!      GT5!    ILR(P) FF1 JZR(FETCH)!
105   103H!      REGC!   NOP(A) JPR(CLR1 AOA CAO TCA ARS ALS LRS SSP
106                              SSN EX EP ES ICX DCX NOPP PZ)!
107   113H!      TCA!    CMR(A)!
108   123H!              ILR(A) FF1 STC JZR(FETCH)!
```

RECORD
NUMBER

```
109   133H!        AGN2!   DSM(R9) JCR(XX)!
110   143H!        AGN3!   DSM(R9) JCR(BACK)!
111   163H!        EQ6!    ILR(P) FF1 JZR(FETCH)!
112   173H!        GT6!    NOP(A) JZR(FETCH)!
113   1E3H!        N4!     NOP(A) JZR(FETCH)!
114   34H!         I!      LMI(AC) RRM!
115   44H!                 ACM(AC)!
116   54H!                 LMI(AC) RRM JPR(LA STA LX STX A1 S1 M D AOM OR1 XOR1
117                               ANDD C EE FF GG)!
118   64H!         SGE!    NOP(A) JCC(SGEC)!
119   74H!         A1!     ACM(AC)!
120   84H!                 ALR(A) STC JZR(FETCH)!
121   0E4H!        SGEC!   NOP(A) JCF(NTEQ5,EQ5)!
122   114H!        ARS!    TZR(A) STC K80000 INH!
123   124H!                DSM(R9)!
124   134H!        XX!     SRA(AC) STZ FFC JFL(OUT2,AGN2)!
125   1D4H!        DWN1!   LMI(R9) FF1 JCR(PUSA4)!
126   1E4H!        N5!     NOP(A) JZR(FETCH)!
127   35H!         J-1     LMI(AC) RRM!
128   45H!                 ACM(AC)!
129   55H!         CL!     SDR(P) FF1 JZR(FETCH)!
130   65H!         SLE!    NOP(A) JCC(SLEC)!
131   75H!         S1!     ACM(AC)!
132   85H!                 CIA(AC) FF1!
133   95H!                 ALR(A) STC JZR(FETCH)!
134   115H!        ALS!    DSM(R9)!
135   125H!                ILR(A)!
136   135H!                DSM(R9)!
137   145H!        BACK!   ALR(A) STC JFL(OUT3,AGN3)!
138   155H!        SLEC!   NOP(A) JCF(NTEQ6,EQ6)!
139   1D5H!        DWN2!   ILR(R8) RWM JCR(DWN1)!
140   1E5H!        TRAP!   NOP(A) JZR(FETCH)!
141   36H!         LI!     LMI(S) FF1!
142   46H!                 ILR(P) RWM!
143   56H!                 LMI(R9) RRM JCR(CLI)!
144   66H!         PUSA!   LMI(R9) FF1 JCC(PUSAC)!
145   /*   LOAD MULTIPLIER    ---MLT--%T      */
146   76H!         M:      ACM(T)!
147   /*   SAVE SIGN BIT IN C FLAG     */
148   86H!                 ILR(T)!
149   8EH!                 SDR(R9) FF1!
150   9EH!                 TZR(A) K80000 INH STC!
151   /*      WIPE OUT SIGN BIT    */
152   96H!                 TZR(T) K7FFFF!
153   /*      SET UP LOOP COUNTER    */
154   0A6H!        .       CLR(AC)!
155   0A5H!                LMI(AC) K0000F!
156   0A4H!                LMI(AC) K00004!
157   0B4H!                CIA(AC) FF1!
158   0B5H!                SDR(R8) FF1!
159   /*      CLEAR PARTIAL PRODUCT     */
160   0C5H!                CLR(AC)!
161   /*      FETCH AND TEST MULTIPLIER    LSB       */
162   0C4H!                SRA(T)!
```

RECORD
NUMBER

```
163  0C2H!     MLP!     LMI(R8) FF1 STZ JFL(MBZ,MB1):
164  /*     ADD SEQUENCE    */
165  0B3H!     MB1!     SDR(R7) FF1 JCR(OV1):
166  0BFH!     Ov1!     ILP(A) FF0:
167  0BEH!              ALR(R7) FF0 JCR(MBZ):
168  /*     SHIFT RIGHT FILL WITH ONES    */
169  0B2H!     MBZ!     SRA(AC) FFC STZ:
170  0B1H!              SRA(T) FFZ JZF(MLP,MEX):
171  /*        APPLY CORRECTION   */
172  0C3H!     MEX!     TZR(R9) K80000 INH JCR(XXX):
173  0C9H!     XXX!     NOP(A) JFL(POS,NEG):
174  0CBH!     NEG!     CMR(A) JCR(OV2):
175  0CDH!     OV2!     ALR(A) FF1:
176  0CAH!     P S!     SDR(A) FF1 JCR(OV3):
177  0CEH!     OV3!     ILR(T):
178  0C1H!              SRA(AC) FF0:
179  0CFH!              SDR(Q) FF1 JZR(FETCH):
180  0B6H!     PUSAC!    ILR(R0) RWM:
181  0C6H!              LMI(R9) FF1:
182  0D6H!              ILR(R1) RWM:
183  0E6H!              LMI(R9) FF1:
184  0F6H!              ILR(R2) RWM:
185  106H!              LMI(R9) FF1 JCC(PUSA2):
186  116H!     LPS!     ILP(A):
187  126H!              DSM(R9) JCC(Z7):
188  136H!     PUSA2!   ILR(R3) RWM:
189  146H!              LMI(R9) FF1 JCC(PUSA3):
190  156H!     Z7!      SRA(AC) STZ JFL(OUT,AGN):
191  152H!     OUT!     ALR(AC) FFZ JCR(WW):
192  153H!     AGN!     DSM(R9) JCR(ZZ):
193  166H!     PUSA3!   ILR(R4) RWM:
194  176H!              LMI(R9) FF1:
195  186H!              ILR(R5) RWM:
196  196H!              LMI(R9) FF1:
197  1A6H!              ILR(R6) RWM:
198  1B6H!              LMI(R9) FF1:
199  1C6H!              ILR(R7) RWM:
200  026H!     LMI(R9) FF1:
201  27H!      ILR(R8) RWM:
202  28H!      LMI(R9) FF1:
203  29H!      ILR(T) RWM JZR(FETCH):
204  1E6H!     N7!      NOP(A) JZR(FETCH):
205  1D6H!              LMI(R9) FF1 JCR(DWN2):
206  37H!      MSC!     NOP(A) JPR(SE SG SL SNE SGE SLE PUSA PUSX POPX
207                          RTN SKN SKP SO SNO SAE DO):
208  57H!      ELI!     LTM(AC) JCR(CL):
209  67H!      PUSX!    LMI(S) FF1 ICC(PUSX1):
210  /*     DIVIDE .........................................    */
211  77H!      D!       CLR(R6):
212  0F7H!              CLR(AC):
213  107H!              LMI(AC) K0000F:
214  127H!              LMI(AC) K00005:
215  137H!              CIA(AC) FF1:
216  147H!              SDR(R8) FF1:
```

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RECORD
NUMBER

```
217  157H!            LMI(R9) RRM:
218  167H!            ACM(AC):
219  177H!            SDR(R9) FF1:
220  187H!            SDP(T) FF1:
221  185H!            ILP(A):
222  184H!            SDR(R2) FF1:
223  /*   START MAIN LOOP, COMPARE SIGN Y WITH SIGN RI    */
224  182H!    DIV!    XNR(R9):
225  181H!            TZR(R9) FF0 K80000 INH:
226  180H!            ILR(R6) JFL(SZERO,SONE):
227  /*   DIFFERENT SIGNS    */
228  192H!    SZERO!  ALR(R6) FF0:
229  191H!            ILR(R2):
230  190H!            ALR(R2) FF0:
231  1A0H!            ILR(T):
232  1B0H!            SDR(R9) FF1:
233  1C0H!            ALR(R2) JCR(OVER):
234  /*   SAME SIGNS    */
235  193H!    SONE!   ALR(R6) FF1:
236  194H!            ILR(R2):
237  195H!            ALR(R2):
238  197H!            ILR(T):
239  1A7H!            SDR(R9):
240  1B7H!            CMR(AC):
241  1B1H!            ALR(R2) FF1:
242  /*   CHECK FOR I=0      */
243  1C1H!    OVER!   LMI(R8) FF1:
244  1C7H!            NOP(A) JFL(DIV,DONE):
245  /*   APPLY CORRECTION    */
246  183H!    DONE!   CLR(AC):
247  188H!            LMI(AC) K80000 FF1:
248  198H!            ALR(R6):
249  1A8H!            SDR(A) FF1 JZR(FETCH):
250  87H!     PUSX1!  ILR(A) RWM:
251  97H!             LMI(S) FF1:
252  0A7H!            ILR(X) RWM:
253  0B7H!            LMI(S) FF1:
254  0C7H!            ILR(P) RWM:
255  0D7H!            LMI(S) FF1:
256  0E7H!            ILR(W) RWM JZR(FETCH):
257  117H!    SSP!    TZR(A) K7FFFF JZR(FETCH):
258  107H!    PUSA6!  ILR(T) RWM JZR(FETCH):
259  1E7H!    R I!    NOP(A) JZR(FETCH):
260  38H!     XK!     ALR(X):
261  48H!             LMI(AC) RRM JPR(LA STA LX STX A1 S1 M D AOM OR1 XOR1
262                                  ANDD C EE FF GG):
263  68H!     POPX!   DSM(S) JCC(POPX1):
264  78H!     AOM!    ACM(AC) FF1 RWM JZR(FETCH):
265  88H!     POPX1!  LMI(S) RRM:
266  98H!             ACM(AC):
267  0A8H!            SDR(W) FF1:
268  0B8H!            DSM(S):
269  0C8H!            LMI(S) RRM:
270  0D8H!            ACM(AC):
```

RECORD
NUMBER

```
271  0E8H!              SDR(P)FF1;
272  0F8H!              DSM(S);
273  108H!              LMI(S) RRM JCC(POPX2);
274  118H!     SSN!     CSR(AC);
275  128H!              ORR(A) K80000 JZR(FETCH);
276  138H!     POPX2!   SDR(X) FF1;
277  148H!              DSM(S);
278  158H!              LMI(S) RRM;
279  168H!              SDR(A) FF1 JZR(FETCH);
280  1D8H!     PUSA5!   LMI(R9) FF1 JCR(PUSA6);
281  1E8H!     SMI!     NOP(A) JZR(FETCH);
282  39H!      JJ!      NOP(A) JZR(FETCH);
283  49H!      RTN2!    ACM(AC) JCR(RTN3);
284  59H!      RTN1!    LMI(S) RRM JCC(RTN2);
285  69H!      RTN!     DSM(S) JCC(RTN1);
286  79H!      OR1!     ACM(AC);
287  89H!               ORR(A) JZR(FETCH);
288  119H!     EX!      SDR(T)  FF1;
289  129H!              ILR(X);
290  139H!              SDR(A) FF1;
291  149H!              ILR(T);
292  159H!              SDR(X) FF1 JZR(FETCH);
293  189H!     DN1!     SDR(T) FF1;
294  199H!              ILR(Q);
295  1A9H!              SDR(A) FF1;
296  1B9H!              ILR(T);
297  1C9H!              SDR(Q) FF1 JZR(FETCH);
298  1D9H!     PUSA4!   ILR(R9) RWM JCR(PUSA5);
299  1E9H!     EQ!      ILR(A) JCC(DN1);
300  1AH!      POS1!    ILR(P) FF1 JZR(FETCH);
301  2AH!      POSS!    NOP(A) JZR(FETCH);
302  /* ENTRY FOR PAGE 2 CENTROID TRACKER */
303  3AH!      CTRACK!  NOP(A) JZR(FETCH) PAGE2;
304  4AH!      RTN3!    SDR(P) FF1 JZR(FETCH);
305  5AH!      SKN1!    NOP(A) JFL(POSS,NEGG);
306  6AH!      SKN!     TZR(A) K80000 INH JCC(SKN1);
307  7AH!      XOR1!    ACM(AC);
308  8AH!               XNR(A) JCR(DWN5);
309  /*  IF A .LT. MEM CF=0 ZF=0, IF A .GT. MEM CF=0 ZF=1
310    IF A .EQ. MEM CF=1 ZF=0    */
311  0AAH!        TSAME!                  NOP(A) JFL(APOS2,ANEG2);
312  0BAH!     NOCRY! NOP(A) JZR(FETCH);
313  0DAH!     NOCRY2!                 NOP(A) FF1 STC JZR(FETCH);
314  0FAH!     APOS2! NOP(A) FF1 STZ JZR(FETCH);
315  10AH!     SP!      ILR(P) FF1 JZR(FETCH);
316  11AH!     EP!      SDR(T)  FF1;
317  12AH!     .        ILR(P);
318  13AH!              SDR(A) FF1;
319  14AH!     ILR(T);
320  15AH!              SDR(P) FF1 JZR(FETCH);
321  16AH!     NSKIP! NOP(A) JZR(FETCH);
322  17AH!     EVEN!    ILR(P) FF1 JZR(FETCH);
323  18AH!     NC!      NOP(A) JFL(NOVEF1,OVEF1);
324  19AH!     NOVEF1!                  NOP(A) JZR(FETCH);
```

```
RECORD
NUMBER

  325  1AAH!      OVEF2! ILR(P) FF1 JZR(FETCH):
  326  1BAH!      NC2!   NOP(A) JFL(NOVEF3,OVEF3):
  327  1CAH!      NOVEF3!                   ILR(P) FF1 JZR(FETCH):
  328  1DAH!      OVEF4! ILR(P) FF1 JZR(FETCH):
  329  1EAH!      N11!   NOP(A) JZR(FETCH):
  330  1BH!       NEG1!  NOP(A) JZR(FETCH):
  331  2BH!       NEGG!  ILR(P) FF1 JZR(FETCH):
  332  3BH!       LL!    NOP(A) JZR(FETCH):
  333  5BH!       SKP1!  NOP(A) JFL(POS1,NEG1):
  334  6BH!       SKP!   TZR(A) K80000 INH JCC(SKP1):
  335  7BH!       ANDD!  ACM(AC):
  336  8BH!              ANR(A) JZR(FETCH):
  337  0ABH!      SAME!  CMP(R8) JCR(DWN7):
  338  0BBH!      CRY!   NOP(A) JFL(NOCRY2,CRY2):
  339  0DBH!      CRY2!  NOP(A) FF1 STZ JZR(FETCH):
  340  0FBH!      ANEG2!  NOP(A) JZR(FETCH):
  341  10BH!      NSP!   NOP(A) JZR(FETCH):
  342  11BH!      ES!    SDR(T)  FF1:
  343  12BH!             ILP(W):
  344  13BH!             SDR(A) FF1:
  345  14BH!             ILR(T):
  346  15BH!             SDR(W) FF1 JZR(FETCH):
  347  16BH!      SKIP!  ILR(P) FF1 JZR(FETCH):
  348  17BH!      ODD!   NOP(A) JZR(FETCH):
  349  18BH!      CR!    NOP(A) JFL(OVEF2,NOVEF2):
  350  19BH!      OVEF1! ILR(P) FF1 JZR(FETCH):
  351  1ABH!      NOVEF2!                   NOP(A) JZR(FETCH):
  352  1BBH!      CR22!  NOP(A) JFL(OVEF4,NOVEF4):
  353  1CBH!      OVEF3! NOP(A) JZR(FETCH):
  354  1DBH!      NOVEF4!                   NOP(A) JZR(FETCH):
  355  1EBH!      N12!   NOP(A) JZR(FETCH):
  356  3CH!       IV!    LMI(R9) RRM:
  357  4CH!              ACM(AC):
  358  5CH!              ALR(X) JCR(CIX):
  359  6CH!       SO!    NOP(A) JCC(SO1):
  360  /*      REGISTER EIGHT IS SET TO STACK POINTER WHEN SIGNS OF MEMORY LOCAT
  361      AND ACCUMULATOR ARE DIFFERENT
  362
  363      REGISTER EIGHT IS SET TO THE DIFFERENCE OF THE MEMORY LOCATION AND THE
  364       ACCUMULATOR WHEN THE SIGNS OF MEMORY LOCATION AND ACCUMULATOR ARE DIFF
  365  ERENT    */
  366  7CH!       C!     ACM(AC):
  367  8CH!              SDR(R8) FF1:
  368  9CH!              SDR(T)  FF1 K80000:
  369  0ACH!             ILR(A) STC:
  370  0BCH!             SDR(R5) FF1 K80000:
  371  0CCH!             ILR(R5) FF0 STZ:
  372  0DCH!             XNR(T)  JCC(CX2):
  373  0ECH!      CX3!   TZR(T)  INH:
  374  0FCH!             TZR(R5) INH JFL(NTSAME,SAME):
  375  10CH!      CX2!   ILR(A) FF0 JCC(CX3):
  376  11CH!      ICX!   ILR(R9):
  377  12CH!             ALR(X):
  378  13CH!             TZA(AC) K80000 INH:
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379  14CH!            NOP(A) JFL(NSKIP,SKIP);
380  16CH!    DWN3!    LTM(AC);
381  17CH!    SOR(A)   FF1 JZR(FETCH);
382  18CH!    SO1!     TZR(A) K80000 INH JCF(NC,CR);
383  1ECH!    DI!      LMI(R9) RIN JCC(DWN3);
384  30H!     AA!      NOP(A) JZR(FETCH);
385  50H!     CIX!     LMI(AC) RRM JPR(LA STA LX STX A1 S1 M D AOM OR1 XOX1
386                              ANDD C FE FF GG);
387  6DH!     SNO!     NOP(A) JCC(SNO1);
388  70H!     EE!      NOP(A) JZR(FETCH);
389  8DH!     DWN5!    CMR(A) JZR(FETCH);
390  0ADH!    DWN7!    ALR(R8) FF1;
391  0BDH!    C XXX!   TZR(R8) JFL(NOCRY,CRY);
392  11DH!    Dcx!     ILR(R9);
393  12DH!             CMA(AC);
394  13DH!             ALR(X) FF1;
395  14DH!             NOP(A) JFL(SP,NSP);
396  19DH!    SNO1!    TZR(A) K80000 INH JCF(NC2 CR22);
397  1DDH!    D N4!    LMI(R9) ROT JZR(FETCH);
398  1EDH!    Dn!      ILR(A) JCC(DWN4);
399  3FH!     COR!     NOP(A)  PAGE2 JCC(DWN8);
400  5EH!     DWN8!    NOP(A) JCC(SAE);
401  6EH!     SAE!     TZR(A) K00001 INH JCC(SAE1);
402  7FH!     FF!      NOP(A) JZR(FETCH);
403  11EH!    NOPP!    NOP(A) JZR(FETCH);
404  16EH!    SAE1!    NOP(A) JFL(EVEN,ODD);
405  1EEH!    HH!      NOP(A) JZR(FETCH);
406  0FH!     FETCH!   LMI(P) FF1 RRM;
407  1FH!             LTM(AC) K01FFF;
408  2FH!             SOR(R9) FF1 JPX(DIR J L REG I JI LI MSC XK JJ
409                              CTRACK LL IX AA COR IO);
410  3FH!     IO!      NOP(A) JCC(IO1);
411  6FH!     DD!      NOP(A) JZR(FETCH);
412  7FH!     GG!      NOP(A) JZR(FETCH);
413  11FH!    P7!      NOP(A) SPO JZR(FETCH);
414  14FH!    IO1!     NOP(A) JCC(JK);
415  1DFH!    JK!      NOP(A) JPR(N1,N2,N3,N4,N5,TRAP,N7,R41,SMI,EO,N11,N12
416                              DI DO HH II);
417  1EFH!    II!      NOP(A) JZR(FETCH);
418  EOF
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